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THE AMENDMENT OF THE LAW RELATING TO LETTERS PATENT FOR INVENTIONS.

IN resuming the consideration of the subject of patent law reform, we purpose on the present occasion directing attention to some points of law and practice which it is desirable, in the interests of all parties, should be clearly defined by parliamentary enactment instead of their being entirely left to the judgment and discretion of judicial tribunals, as is the case at present.

The points to which we refer are involved in the answers to the following questions, viz:—

1. What is a sufficient description of an invention for a complete specification?
2. What constitutes a publication?
3. What constitutes a public user?

In the celebrated telephone case—*The United Telephone Company, Limited, v. Harrison, Cox-Walker & Co.*—when before the Court of Appeal, the whole of these questions were ardently discussed by counsel on both sides and by the bench, and the difference of opinion which existed among eminent legal authorities plainly showed the necessity for a positive ruling on each of these several points.

1. With regard to the first question, what is a sufficient description of an invention for a complete specification? the late deeply lamented Master of the Rolls observed that it is not requisite that a specification should explain the *modus operandi* of a machine or instrument, but all that is necessary is that the invention should be so described that a competent person will be able to make the machine or instrument from the description. And that learned judge instanced the case of a flute which he assumed, for the purpose of argument, as a new invention, and stated that if the patentee described the construction of the flute and said "there is a new wind instrument," and did not explain where the user was to blow or how he was to play it, nevertheless that would be a sufficient specification. It is not at all necessary, Sir G. Jessell added, that the public should know how to use the machine or instrument; if they can make it from the description, the patentee has complied with the requirements of the law. These legal dicta which, of course, must be accepted as coming from so high an authority, took many persons by surprise, as it has been always considered that the object of the patent laws was to secure to the public the advantage of inventions after the expiration of the term of the patent, and it is difficult to see how that condition is realised unless the public are placed in beneficial possession of the whole of the secret.

2. With respect to the second question, "publication," Sir G. Jessell took a similar view, which, it must be confessed, was quite consistent with himself. He held that it was not necessary in order to constitute a publication of an invention for a machine or instrument that the public should understand

how the machine or instrument is operated or used; but that if sufficient information is given to enable competent persons to manufacture, the publication must be admitted.

It follows, then, from this ruling that a description which would not be sufficient to place the public in such beneficial possession of an invention that they would be able to carry it into practical effect will yet operate as a publication, and will thus be a bar to obtaining a subsequent valid patent even although the specification of the latter may be much more full and complete than the description which constitutes the publication in question.

On the 3rd point, "What constitutes a public user?" the late Master of the Rolls also expressed some very decided opinions, among others that the use of a machine constituting an invention in public is none the less a *public* user of the invention if the machine is boxed up or enclosed so that no person can see its construction. Take the case of a locomotive running on a railway, said Sir G. Jessell, that is a public user even although not a single individual except the makers have ever seen its working parts. These dicta are no doubt supported by judicial precedent, but it is questionable whether they are based upon sound principles of public policy.

Another and analogous question which is sometimes raised is whether a valid patent can be obtained for a material which has been exhibited, and even sold, but the composition of which cannot be determined by inspection or analysis. The letter of the law as it at present stands is clearly opposed to the validity of patents of this class, but when we recollect the possibility of the inventors dying without disclosing their secrets, in which case the public will not be one whit the wiser than if they had never seen the material, it is evident that it would be worth while to grant patents in such cases, and thus secure the possession of inventions which otherwise might be irrecoverably lost to the world.

In connection with the *sufficiency* of specifications we may advert to a collateral branch of the subject, viz., the *construction* of specifications, in considering which we are reminded of the marked contrast between the present system of construing specifications adopted by the courts, and the system which was in vogue in the earlier days of the existence of patents. Formerly a patent was looked upon as a sort of unwelcome intruder which was to be got rid of by any available means, and hence when a specification came to be construed by the courts, the main object seemed to be to try to "pick holes in it," and by a microscopical examination to discover flaws which could not be seen by the unaided mental vision—in fact to make apparent imaginary defects and to magnify the importance of real ones. Now, however, the courts favour what has been termed a benevolent, or benignant interpretation of the specification, and endeavour by all lawful means to support a patent for a *bonâ fide* invention, even in some cases straining a point on its behalf instead of adopting the contrary course.

While, however, it is obvious that no rule of universal application can be laid down for the construction of specifications, yet it is a question whether the discretionary power of judicial tribunals should not be more effectually controlled by legislative enactment. Even in this case, however, much must be left to the judgment of the courts, which should take into consideration all the circumstances of each particular case and determine it upon its own merits.

When the invention is of a decidedly novel and original character, in fact, like the telephone, so unique in its nature that its publication marks an epoch in the cycle of science, it is perhaps unreasonable to look for that accuracy and fullness of description which may fairly be expected when the invention is simply an improvement in a well-known field of labour. As an example, on the other hand, take the steam-engine with all that is known at the present day of the nature and properties of steam, and of the principles of its application for the purpose of obtaining motive power. Now, a man who applies for a patent for a slight improvement in the steam-engine can plead no excuse if his description is unscientific and erroneous, as he is supposed to avail himself of the common stores of knowledge which are open to all the world. In the case, however, of an invention which forms a new departure in the tracks of science, it is scarcely fair to expect in the infancy of the discovery that accuracy of description and logical order and sequence in the arrangement of the specification for which we are justly entitled to ask in the case of, say, an improvement in the steam-engine such as we have assumed.

Supposing even that the patentee is mistaken in the theory of his invention, enunciated in his specification, although it is always safer to avoid theorising as much as possible, yet it is manifestly an act of injustice to deprive him of the benefit of his invention because he could not accurately define the principles which underlay it when it was in an embryo condition. The question is, in comparing an alleged infringement with the original invention, is the same result obtained in both by the employment of substantially the same means? If so the inventor should not be prejudiced because with no intention of misleading the public, but honestly with a desire to give them the benefit of all the knowledge he possessed at the time, he committed himself to a theory which further experience has proved to be untenable. The theory may be wrong, but the results are undeniable, and although sound theory is a great desideratum, yet the origination and practical development of a genuine invention, which may create quite a revolution in arts or manufactures, is quite consistent with the most dim, imperfect, and even erroneous views as to the principles of its operation; and the inventor should not be prejudiced because he failed to give the public the benefit of more light than he possessed at the time as to the *rationale* of his invention. At the same time we are of opinion that the requirements of a specification should be more accurately defined than is the case at present, in order that both patentees and the public may at least be informed what are the rules which will guide the judicial tribunals in their decisions. The uncertainty of the law is proverbial, but there is no branch of it which seems more at the mercy of whim and caprice than that which relates to letters patent for inventions. These points should, therefore, not be overlooked in any complete measure of patent law reform.

In making the foregoing observations we wish it to be understood that we do not enter at all into the questions as between the plaintiff company and the defendants in the recent suit, with which we here have nothing to do. We are simply advocating general principles, which we contend should be laid down by the legislature instead of being left to the bias or idiosyncracies of the judge who may happen to preside over the trial of any particular case.

T. J. HANDFORD.

Sixpenny Telegrams.—In the House of Commons on Thursday week the Chancellor of the Exchequer, in the course of his Budget speech, said:—"After the resolution of March 29th, I do not think it would be respectful on my part to put out of the question the proposed reduction in the price of telegrams (cheers). As I promised, I have already commenced a careful inquiry into the estimates made by the Post Office of the cost under several plans of reduction to the *minimum* charge of 6d. At this moment I will not anticipate the result of this inquiry. I propose to set aside £170,000 out of my balance to enable me to carry this out during the course of the present year (cheers)." This result we briefly reported in our last issue.

ON SECONDARY BATTERIES.*

By GEORGE F. BARKER.

A SECONDARY battery is one which produces a current in consequence of a previous electrolytic condensation or polarisation upon the surfaces of its plates. Electrolytic polarisation and the production of a secondary current by means of it, are almost as old as the voltaic battery itself. In 1801, Gautherot, having used platinum or silver wires as electrodes in a solution of salt, noticed a momentary inverse current when the battery was replaced by a galvanometer. Ritter observed the same phenomenon in 1803 with gold wires. He constructed a secondary battery with pieces of gold separated by cloth discs moistened with salt water. After contact for some seconds with a Volta's pile of more pairs than itself, it produced a current to which Ritter gave the name of secondary current. Platinum, gold and silver, gave a more marked result than copper, brass, iron, or bismuth; and no effect at all was obtained from lead, tin or zinc. Fifty discs of copper separated by discs of cloth moistened with salt or sal ammoniac solution, when charged with a Volta's pile of 100 pairs, gave a current which decomposed water and produced all the effects of the primary current. Volta himself, as well as Marianini, explained the results by supposing that the decomposition of the salt produced acidic and basic deposits upon the metal discs; a view which Becquerel apparently confirmed by immersing a platinum plate in an acid and another in an alkali, and noting that the current was the same in direction as the secondary current. But in 1826 De la Rive obtained the secondary effect from platinum plates immersed in dilute sulphuric acid; and since no basic or acidic deposits were now possible, he regarded the phenomenon as a physical one due to a special or polarised condition of the plates themselves. The current he called a polarisation current. In 1833-4, Faraday's researches on electro-chemical decomposition definitely established the proportionality of the current to the amount of electrolyte decomposed. He observed the "peculiar state" of the plates in his voltmeter; and even noticed that when lead acetate was electrolysed, metallic lead was deposited on the negative plate and lead peroxide on the positive; but he offered no explanation of these phenomena. In 1842, Grove, following out an observation of Matteucci, constructed a gas battery in which the current was produced from two plates of platinum immersed in oxygen and hydrogen gases respectively. In 1852, C. W. Siemens used two carbon plates in lead acetate solution as a secondary battery; obtaining, by the action of the current, lead on one of these plates and lead peroxide on the other. One cell of this battery decomposed water; so that the electromotive force of the current must have been nearly two volts.

In 1859, Planté began an elaborate research upon this secondary action, studying carefully the influence of the metal and of the solution employed. The maximum effect was given by lead plates immersed in dilute sulphuric acid; and in 1860, he produced secondary batteries of remarkable power by rolling two sheets of lead together, a strip of insulating material being between them, and placing them in a 10 per cent. sulphuric acid. When connected with a battery, the oxygen evolved upon the positive plate attacked it and converted its surface into peroxide; the hydrogen for the most part escaping. When now the current was reversed, the hydrogen reduced this peroxide to finely-divided metallic lead and the oxygen attacked the other plate, producing peroxide. By such alternations, the metal may finally be corroded to any depth, and the amount of finely-divided lead and peroxide indefinitely increased. In Planté's experiments this forming process required three months. In 1881, Faure brought out a secondary battery in which, as in Planté's, lead plates in sulphuric acid were employed. But in order to avoid the tedious process of "forming," in which the deposits upon the plates were produced by electric action, Faure covered the plates at the outset with a layer of minium or red lead. Upon passing the current, this red lead was re-

* Abstract from the "Proceedings of the American Association for the Advancement of Science," vol. xxxi., Montreal Meeting, August, 1882.

duced to metallic lead on the one plate and oxidised to peroxide on the other; thus producing the battery charged and ready for use in a single operation requiring but a few hours.

The theory of the storage of energy by secondary batteries is not difficult. Energy is capacity of doing work and work is force acting through distance. Whenever two attracting bodies are separated work is done upon the system, and energy is absorbed by it; and this whether the attraction overcome is mechanical, molecular or atomic. When an electrolyte is decomposed by an electric current, the current yields energy in proportion to the amount of the ions separated. The quantity of lead peroxide formed in a secondary battery represents the amount of energy stored from the current. So soon, however, as the separating force ceases to act, the ions reunite and the stored energy becomes again free. Since the amount of energy thus set free, like that originally stored up, is proportional to the quantity of matter concerned, it is clear that the amount of electricity obtained from a given secondary battery is proportional to the amount of electrolytic products deposited upon its plates. In theory, the electrical energy set free should equal that originally stored up; but in practice this result is never attained.

In its primary expression the chemistry of the secondary battery is simple. In the form made by Grove, two platinum plates are placed in acidulated water. Under the action of the current, oxygen is set free on one of these and hydrogen on the other,* and the plates are said to be polarised. The electromotive force between these plates is the sum of the contact-potentials involved. Its value is 1.45 volts, and it measures the chemical attraction between oxygen and hydrogen. If now the two plates be connected by a wire, the oxygen and the hydrogen recombine and the energy of combination appears in the form of a secondary current. In general, however, the electrolytic action is accompanied by secondary chemical changes which render the phenomenon much more complicated. In the lead battery, for example, secondary products appear at both electrodes. The oxygen set free at the anode combines with the lead, the final product there being peroxide. The hydrogen evolved at the cathode reduces the oxide which it finds there and produces metallic lead. As before, the electromotive force in the battery is the sum of the contact-potentials; and this, in the case of lead and lead peroxide, is a little above two volts.† When now the plates are connected by a conductor, the entire process is reversed. Water is decomposed, and, since the immersed portion of the plates changes sign on discharge, the hydrogen now goes to the peroxide surface and oxygen to the finely divided metallic lead. The former is deoxidised to monoxide and the latter oxidised to the same condition. Simultaneously, a current flows through the conductor, the electromotive force of which is two volts, the strength of which is the ratio of this electromotive force to the resistances in circuit, and the duration of which depends upon the amount of secondary products deposited upon the plates during the charging. Beside this, however, another action takes place in the secondary battery which is of great importance. The sulphuric acid in which the plates are immersed attacks both the peroxide on the one plate and the metallic lead on the other, and converts both into lead sulphate. Moreover, as fast as the monoxide is produced by the discharge of the battery, it also is converted into sulphate. So that upon complete discharge, the plates are precisely alike, both being covered with lead sulphate.

The secondary batteries employed for experiment were those of Planté and Faure. Of the former type, two cells of the larger size made by Breguet were used. Of the latter one cell of medium size made by Reynier, and 34 cells of the size exhibited at the Electrical Exhibition at Paris, were experimented with. The battery of 34 cells was made in January under my direction.‡ Each cell

consisted of six plates, each 20 by 60 centimetres, the lead being a millimetre thick. The exposed surface of each plate, therefore, was nearly 0.25 of a square metre, and of each cell about 1.50 square metres. For the whole battery the surface was about 50 square metres (exactly 48.96). Each plate was covered on both sides with a coating of red lead about a millimetre thick made into a paste with water. Parchment paper was then folded over the whole, and over this a covering of felt sewed together at the edges. The plates were then folded transversely and each pair intercalated. Heavy lead terminals were attached to each plate, and three pairs of plates were placed in each box, the terminals of one plate of each pair being united together and furnished with a connector. The boxes were lead-lined, and measured 31 cm. in length, 25 in depth, and 11 in width. One of the two sets of plates was in contact with the lead lining, the other was insulated. The latter was always made the positive end. The total weight of a single cell was 17 kilograms.*

The charging current was generated by a Gramme machine whose field was maintained by an auxiliary dynamo. The maximum obtainable electromotive force of this current was 85 volts. In general, however, a much less electromotive force was used, sufficient only to give a current of from 10 to 20 amperes through the 34 cells arranged in series. Currents as high as 45 amperes, however, were occasionally employed. At the outset, considerable difficulty was experienced from the discharge of the battery when from any accidental cause the current fell below the potential of the 34 cells. The wear of the brushes of the auxiliary dynamo sometimes opened its circuit and thus destroyed the magnetic field of the Gramme. There being now no counter-electromotive force to oppose it, the secondary battery current flowed back through the machine, discharging the battery completely. A simple device was arranged to prevent loss of the charge in this way should the charging current become weakened. This device is represented in fig. 1, where A is a coil of No. 10 copper wire. Within its core is a rod of iron, B, prolonged at both ends by brass rods of smaller diameter, b and c, these being supported upon rollers. Opposite the end of one of these rods is a flat spring, s, faced with platinum and making contact when depressed with a similar brass strip, d, also faced with platinum. The course of the current is shown by the dotted lines. When the circuit is closed between s and d, the current traversing the coil draws the iron bar strongly into its axis, and the end of the brass rod pressing against s holds the circuit closed. Should the current weaken, the spring, s, reacts against the rod, pushing it back and opening the circuit. By means of an auxiliary spiral spring, e, the instrument may be adjusted to any required current-strength. It would seem that by no possibility can the accumulated charge in the battery be lost, when this automatic cut-out is in circuit. As now described, the coil is of large wire, and the entire current passes through it. But a second form of it has been used in which the coil is made of finer wire and is placed in a shunt circuit as shown in fig. 3.

* Mr. W. Lachlan, the electrical engineer of the Light and Force Company, of New York, has kindly furnished me the following figures concerning the Faure batteries of improved construction recently imported in the steamer *Labrador*. Four types of Faure batteries are made in Paris, called A, B, C and D. Type A consists of seven positive plates, each 37×23.5 cm. and 3 mm. thick, perforated with holes 6 mm. in diameter 10 mm. apart, alternated with seven negative plates of the same size, but only 0.5 mm. thick, and similarly perforated. The seven positive plates weigh 16.66 kilograms; the seven negative ones 2.77 kilograms. The red lead spread on their surfaces weighs 22.13 kilograms, the two exterior plates being covered only on their interior surfaces, so that there are 26 active surfaces in all. Each plate has an electrode 7 cm. wide. The box is $45 \times 20 \times 40$ cm. in size, is pitched throughout, and weighs, with its cover, 10 kilograms. The battery complete, ready for charging, weighs 63 kilograms. In type C there are five positive plates each 24×19 cm., 3 mm. thick, and four negative plates 0.5 mm. thick, both perforated with holes 5 mm. in diameter, and a centimetre apart. The positive plates weigh 7.14 kilos., the negative 0.888 kilos. Sixteen surfaces are covered with red lead, weighing 8.28 kilos. The electrodes are 3.5 cm. wide. The box weighs 3 kilos. and the battery complete 20.37 kilos. Each cell of type A contains, it is claimed, when fully charged, 375 ampère-hours of current delivered at an electromotive force of 2 volts. Hence it will furnish, for example, a current of 25 amperes for 15 hours. Type C contains 150 ampère hours. Types B and D are round cells in jars of earthenware. The former weighs 35 kilos. and contains 225 ampère-hours; the latter 8 kilos. and contains 75.

* Undoubtedly the oxygen is produced by a secondary reaction.

† Planté observes that, after complete charging, the electromotive force may rise above two volts at the instant of removing the battery. But as it falls to this value at once on closing the circuit and remains so, he attributes the first result to the temporary production of a peroxidised substance, as hydrogen peroxide or persulphuric acid, at the anode.

‡ This battery, as well as the cut-out, fig. 1, was made by Jas. W. Queen & Co., of Philadelphia.

In both cases of course the entire current passes through the contact springs.*

After charging, the current from the secondary battery was used to maintain 17 Edison incandescent lamps of the B pattern. More frequently, however, the battery was used in connection with the Gramme machine. The source of power being an Otto gas engine which, at best, has an explosion only every fourth stroke, the motion appears very irregular when tested by so delicate a method. As every explosion increases the speed, the higher electromotive force developed increases for an instant the brightness of the carbon filament, producing a marked pulsation in the light. If now a secondary battery of nearly the same electromotive force be placed in multiple circuit with the machine and lamps, it acts as an equaliser, and destroys entirely the pulsations. Figs. 2 and 3 show the arrangement actually

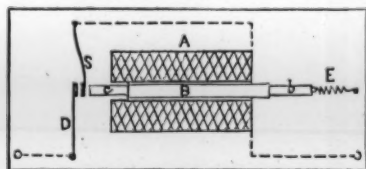


FIG. 1.

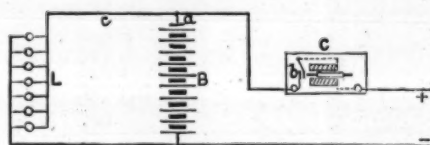


FIG. 2.

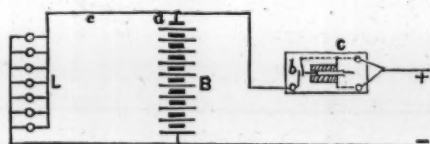


FIG. 3.

employed, in which B is the secondary battery and L the lamps; the automatic cut-out being at c. When the circuit is opened at a, b and c being closed, the lamps are fed by the machine alone; when opened at b, a and c being closed, by the battery alone; when at c, a and b being closed, the machine charges the battery. When all three are closed, the lamps are fed by the machine and battery together, the latter acting as an equaliser. A galvanometer inserted at a, c being opened and b closed, indicates the charging current; when c is closed and b open, the discharge current; and when b and c are both closed, the equalising current. If the electromotive force of the machine current be but slightly in excess of the battery current, the deflection to the right in the first case will about equal that to the left in the second; so that in the third case the deflection is practically zero, not the least spark appearing on opening at a; and this, though the pulsations are completely destroyed, the light being perfectly steady. The advantage of a much more agreeable light is thus secured; but, in addition, the life of the lamps must be increased by the use of this steadier current, as it has been shown to be by using the secondary battery alone.

On February 27th the battery was charged continuously for 14 hours, or until hydrogen was freely evolved from each of the 32 cells employed. It then gave an electromotive force of 59.3 Daniell cells; or, calling the Daniell 1.08 volts, of 64.04 volts. On June 10th the same 32 cells gave an electromotive force of 56.7 Daniells, or 61.2 volts. On June 24th their electromotive force was 54.3 Daniells, or 58.6 volts. It may be assumed then that the average electromotive force of a single cell was not far from two volts. This value has never been exceeded in any of the measurements made, either on single cells or on groups of cells. When first made, the resistance of the single cells was low, about 0.02 ohm; but subsequently the

internal resistance increased considerably, rising even to twice this value.

The chief defect of the secondary lead battery is the local action which takes place in it. By local action is meant any deterioration in the efficiency of a battery which occurs when it is left on open circuit. This defect was noticed by Planté, who says:—"If the lead peroxide deposited on the positive plate had no tendency to spontaneous reduction in the acidulated water, by forming a local circuit with the metal that it covers, the preservation of the charge taken by the secondary couple should be indefinite. But this peroxide is reduced, and with the more facility as the layer of it is thinner. In a new secondary couple the charge cannot be preserved." In a well-formed battery he attributes the preservation of the charge to a reduction of the superficial layer to monoxide, which acts as a protecting coating. Another local action, however, takes place in this battery, which appears to be of more importance. This is the action of the sulphuric acid upon the products of electrolysis. The finely-divided lead on the negative plate, as well as the peroxide upon the positive, is alike converted into sulphate by this action. When the circuit is closed this action is normal; but it takes place equally well when the circuit is open. It is then abnormal, and of course injurious. The formation of lead sulphate in the secondary battery has been studied by Gladstone and Tribe.* They found that with a Planté cell the whole of the peroxide formed on charging was converted into white sulphate within seventeen hours. The same fact was observed with the Faure battery. So far, however, from regarding this formation of sulphate as wholly injurious, they regard it as "absolutely requisite in order that the charge should be retained for a sufficient time to be practically available." They believe that the insoluble lead sulphate clogs up the interstices of the peroxide and after awhile forms an almost impermeable (*sic*) coating between it and the lead plate; so that the mass of peroxide which is in contact with the lead plate expends its energy slowly, while the same mass of peroxide, brought into connection through its own lead plate with another lead plate at a distance, expends its energy even through the sulphuric acid, in a tenth or a hundredth part of the time.

My experiments with the Faure battery above described confirm entirely those of Gladstone and Tribe as to the formation of lead sulphate. In several cases the acid in charged cells disappeared entirely on standing, so that the water was tasteless; and in some instances this was repeated three times with the same set of plates. This action increased very greatly the internal resistance, first by replacing the acid by water, and second by forming the higher resistant sulphate. On examining the plates, lead sulphate formed the entire coating upon both of them. On attempting now to recharge such a cell, this notable increase in the resistance showed itself in the reduced current transmitted by the same electromotive force. Gradually, however, the resistance fell and the current finally regained its normal strength. In one instance the charging current rose from two amperes to 12, in four hours, 28 cells being in circuit, arranged in series. It was observed, however, that when the current was first applied torrents of gas were evolved from both plates; and that as the charging process went on the oxygen was first completely absorbed and then the hydrogen. When the charge was nearly complete the evolution of hydrogen reappeared. There would seem, therefore, to be a very considerable loss of energy, due to the resistance consequent upon the formation of sulphate. In the first place the current energy is wasted as heat in the cells; and in the second, a large proportion of it is dissipated in the evolved gases.

Another defect of considerable magnitude is developed when a number of secondary cells is placed in series, and is due to a want of uniformity in their capacity for storage. This arises probably, first, from the difficulty of constructing them exactly alike originally; and second, from the impossibility of uniform action among them on charge and discharge. The difference in the cells of the same battery even, when they all have been treated precisely alike, is surprising. On the 14th of June, 32 cells were freshly charged, and the current strength from each cell measured on a

* Sir Wm. Thomson has devised a polarised cut-out for this same purpose. He exhibited it at the York meeting of the British Association in September last.

* *Nature*, xxv., 221, 461; xxvi., 251, 1882.

tangent galvanometer. Eleven cells gave 80° deflection each, 17 gave 79° each, one gave 78° , one 77° , one 75° , and one 20° . When 17 Edison B lamps were placed in circuit, the discharge deflection of the 32 cells in series was 67° . On the following day the battery was charged again, and, after an hour's use on the lamp circuit, was again tested. Those giving a deflection of 87° were two; of 86° , two; of 84° , two; of 83° , one; of 81° , one; of 78° , five; of 77° , two; of 76° , one; of 13° , three; of 11° , one; of 10° , three; of 8° , one; of 6° , one; of 5° , three; of 4° , one; of 2° , one; of 1° , one; and of 0° , one. Obviously, so long as any peroxide is present, the electromotive force is constant; hence this wide variation of current strength must be attributed apparently to the variation of the resistance in the different cells. But this is not the worst aspect of the matter. If the discharge be continued for a longer time, some of the cells become exhausted sooner than others, and are then charged in the inverse direction by the current from the rest. On June 12th, the 32 cells, after pretty complete discharge, were measured as above. Nineteen cells gave positive deflections ranging from 87° to 5° ; 13 gave negative deflections varying from 13° to 1° . Faraday said of primary batteries, in 1834, that "weak and exhausted charges should never be used at the same time with strong and fresh ones in the different cells;" and this remark is even more applicable to secondary batteries, where this condition is more liable to occur. Not only does a dead cell introduce resistance into the circuit, but what is of more importance, its reverse polarisation introduces a counter-electromotive force, so that every such cell neutralises another cell, the dead resistance of which is also added to the circuit. In consequence, it is not safe in practice to draw from a secondary battery all the energy it should be capable of yielding, and in most cases not more than half can be safely taken out of it. In place of continuing uniform as in a single cell, the electromotive force of a series of cells begins to fall when about half the charge which it ought to be capable of yielding has been drawn from it. The practical result is that to supply for lighting a definite number of coulombs of electricity a secondary battery of twice the size is necessary under these circumstances.

With reference to the two forms of lead secondary battery devised by Planté and by Faure respectively, my experiments show that while the electromotive force is the same in both, and while the internal resistance and storage capacity may readily be made the same, yet that the local action is far less when the peroxide is formed by the action of the current upon the lead plate itself than when it is produced from minium spread upon it. The rapidity of the formation of the peroxide is proportional to the density of the current; but when rapidly formed it is fine and spongy. In one of my Planté cells, the peroxide is beautifully crystalline and very hard. Not a trace of sulphate has been formed in it apparently, though it has been in use for six months, and has been frequently charged and discharged during that time. The necessarily finer condition of the peroxide in the Faure battery would seem to predispose it to a more considerable local action. True, the Faure battery requires very much less time than the Planté to form it. But this is more than compensated by the increased permanence of the latter. With an equal storage capacity, as in M. de Kabath's form of Planté cell, it would appear that in efficiency it will surpass the form devised by Faure.

The commercial aspect of the question of the storage of electrical energy has recently assumed a very considerable importance. But it is evident at the outset, that an agent, which has been produced and then stored, must cost more when redelivered than when first produced, by exactly the cost of the storage; that is supposing there is no loss in storing. But there is a loss, and this is almost if not quite one-half of the energy involved; as it would seem from the Conservatoire experiments in Paris, among others. The first cost of the accumulators, the expense of charging them, their low efficiency, and especially their bulk and weight, must ever prevent, it would seem, their competing successfully with the direct use of the dynamo-electric machine, at least with any form of secondary battery yet devised. For special uses, however, the storage battery has a high value. Even if the cost of an ampère of current produced by it is twice as great as if produced directly by the dynamo machine, this cost is only one-half of that required to give the same

current by any available form of primary battery. Where a strong current of low electromotive force is needed, under conditions where a dynamo cannot be employed, there the secondary battery has its most important field. Its value rapidly decreases as the number of cells is multiplied, as when a high electromotive force is needed for the production of light. Its chief advantage is its transportability; since by placing it near the work to be done, the loss of energy on long conductors is obviated.

LECTURES ON ELECTRICAL SCIENCE.

THE fourth of the series of six lectures on the Applications of Electricity was delivered on Thursday evening, the 5th of April, by Dr. John Hopkinson, F.R.S., M. Inst. C.E., before the members of the Institute of Civil Engineers. The subject was "Some Points in Electric Lighting." The following is an abstract of the lecture:—

The science of lighting by electricity was divided by the lecturer into two principal parts—the methods of production of electric currents, and of conversion of the energy of those currents into heat at such a temperature as to be given off in radiations to which the eye was sensible. The laws known to connect together those phenomena called electrical, were essentially mechanical in form, closely correlated with mechanical laws, and might be most aptly illustrated by mechanical analogues. For example, the terms "potential," "current," and "resistance," had close analogues respectively in "head," "rate of flow," and "co-efficient of friction" in the hydraulic transmission of power. Exactly as in hydraulics head multiplied by velocity of flow was power measured in foot-pounds per second or in H. P., so potential multiplied by current was power and was measurable in the same units. Again, just as water flowing in a pipe had inertia and required an expenditure of work to set it in motion, and was capable of producing disruptive effects if that motion were too suddenly arrested, so a current of electricity in a wire had inertia; to set it moving electromotive force must work for a finite time, and if arrested suddenly by breaking the circuit the electricity forced its way across the interval as a spark. Corresponding to mass and moments of inertia in mechanics there existed in electricity co-efficients of self-induction. There was, however, this difference between the inertia of water in a pipe and the inertia of an electric current—the inertia of the water was confined to the water, whereas the inertia of the electric current resided in the surrounding medium. Hence arose the phenomena of induction of currents upon currents, and of magnets upon moving conductors—phenomena which had no immediate analogues in hydraulics.

The laws of induction were then illustrated by means of a mechanical model devised by the late Professor Clerk Maxwell.

In the widest sense, the dynamo-electric machine might be defined as an apparatus for converting mechanical energy into the energy of an electro-static charge, or mechanical power into its equivalent electric current through a conductor. Under this definition would be included the electrophorus and all frictional machines; but the term was used in a more restricted sense, for those machines which produced electric currents by the motion of conductors in a magnetic field, or by the motion of a magnetic field in the neighbourhood of a conductor. The laws on which the action of such machines was based had been the subject of a series of discoveries. Oersted discovered that an electric current in a conductor exerted force upon a magnet; Ampère that two conductors conveying currents generally exerted a mechanical force upon each other; Faraday discovered—what Helmholtz and Thomson subsequently proved to be the necessary consequence of the mechanical reactions between conductors conveying currents and magnets—namely, that if a closed conductor moved in a magnetic field, there would be a current induced in that conductor in one direction, if the number of lines of magnetic force passed through the conductor was increased by the movement, in the other direction if diminished. Now all dynamo-electric machines were based on Faraday's discovery. Not only so; but however elaborate it might be desired to make the analysis of the action of a dynamo machine, Faraday's way of presenting the phenomena of electromagnetism to the mind was in general the best point of departure. The dynamo machine, then, essentially consisted of a conductor made to move in a magnetic field. This conductor, with the external circuit, formed a closed circuit in which electric currents were induced as the number of lines of magnetic force passing through the closed circuit varied. Since, then, if the current in a closed circuit was in one direction when the number of lines of force was increasing, and in the opposite direction when they were diminishing, it was clear that the current in each part of such circuit which passed through the magnetic field must be alternating in direction, unless, indeed the circuit was such that it was continually cutting more and more lines of force, always in the same direction. Since the current in the wire of the machine was alternating, so also must be the current outside the machine, unless something in the nature of a commutator was employed to reverse the connections of the internal wires in which the current was induced, and of the external circuit. There were then broadly two classes of dynamo-electric machines; the simplest, the alternating-current machine, where no commutator was used; and the continuous-current machine, in which a commutator was used to change the connection with the external circuit just at the moment when the direction of the current would change. The theory of the alternate-current machine was then explained, and it was proved that two independently driven alternate-current machines could not be worked in series, but that they might be worked in parallel circuit, and hence were quite suitable for distribution of

electricity for lighting without the necessity of providing a separate circuit for each machine.

It was easy to see that, by introducing a commutator revolving with the armature, in an alternate-current machine, and so arranged as to reverse the connection between the armature and the external circuit just at the time when the current would reverse, it was possible to obtain a current constant always in direction; but such a current would be far from constant in intensity, and would certainly not accomplish all the results obtained in modern continuous-current machines. This irregularity might, however, be reduced to any extent by multiplying the wires of the armature, giving each its own connection to the outer circuit, and so placing them that the electromotive force attained a maximum successively in the several coils. A practically uniform electric current was first commercially produced with the ring armature of Pacinotti, as perfected by Gramme. A dynamo machine was not a perfect instrument for converting mechanical energy into the energy of electric current. Certain losses inevitably occurred. There was the loss due to friction of bearings, and of the collecting-brushes upon the commutator; there was also the loss due to the production of electric currents in the iron of the machine. When these were accounted for, there remained the actual electrical effect of the machine in the conducting wire; but all of this was not available for external work. The current had to circulate through the armature, which inevitably had electrical resistance; electrical energy must, therefore, be converted into heat in the armature of the machine. Energy must also be expended in the wire of the electro-magnet which produced the field, as the resistance of this also could not be reduced beyond a certain limit. The loss by the resistance of the wires of the armature and of the magnets greatly depended on the dimensions of the machine. To know the properties of any machine thoroughly, it was not enough to know its efficiency and the amount of work it was capable of doing; it was necessary to know what it would do under all circumstances of varying resistance or varying electromotive force; and, under any given conditions, what would be the electromotive force of the armature? Now this electromotive force depended on the intensity of the magnetic field, and the intensity of the magnetic field depended on the current passing round the electro-magnet and the current in the armature. The current then in the machine was the proper independent variable in terms of which to express the electromotive force. The simplest case was that of the series-dynamo, in which the current in the electro-magnet and in the armature was the same, for then there was only one independent variable. The relation between electromotive force and current might be most conveniently expressed by a curve.

When four years ago the lecturer first used such a curve (since named by Deprez the "characteristic curve") for the purpose of expressing the results of his experiments on the Siemens dynamo machine, he pointed out that it was capable of solving almost any problem relating to a particular machine, and that it was also capable of giving good indications of the results of changes in the winding of the magnets, or of the armatures of such machines. The use of the characteristic curve was illustrated with reference to charging accumulators and Jacobi's law of electric transmission of power.

When the dynamo machine was not a series-dynamo, but the current in the armature and in the electro-magnet, though possibly dependent upon each other were not necessarily equal, the problem was not so simple. In that case there were two variables, the current in the electro-magnet and the current in the armature; and the proper representation of the properties of the machine would be by a characteristic surface, of which a model was exhibited. By the aid of such a surface any problem relating to a dynamo machine could be dealt with, no matter how its electro-magnets and its armature were connected together. Of course in actual practice the model of the surface would not be used, but the projections of its sections.

The properties of a machine depended much upon its dimensions. Suppose two machines alike in every particular, excepting that the one had all its linear dimensions double that of the other. The electrical resistances in the larger machine would be one-half those of the smaller. The current required to produce a given intensity of magnetic field would be twice as great in the larger machine as in the smaller. The comparative characteristic curves of the two machines, when driven at the same speed, were shown in a diagram. The two curves were one the projection of the other, having corresponding points with abscissas in the ratio of one to two, and the ordinates in the ratio of one to four. At first sight it would seem that the work done by the larger machine should be thirty-two times as much as that which would be done by the smaller. Practically, however, no such result could possibly be attained for many reasons. First, the iron of the magnets became saturated, and consequently instead of eight times the electromotive force, there would only be four times the electromotive force. Secondly, the current which the armature could carry was limited by the rate at which the heat generated in the armature could escape. Again, the larger machine could not run at so great an angular velocity as the smaller one. And lastly, since in the larger machine the current in the armature was greater in proportion to the saturated magnetic field than in the smaller one, the displacement of the point of contact of the brushes with the commutator would be greater. Shortly, the capacity of similar dynamo machines was pretty nearly proportionate to their weight, that was to the cube of their linear dimensions; the work wasted in producing the magnetic field was directly as the linear dimensions; and the work wasted in heating the wires of the armature was as the square of the linear dimensions.

A consideration of the properties of similar machines had another important practical use. Mr. Froude was able to control the design of ironclad ships by experiments upon models made in paraffine-wax. It was a much easier thing to predict what the performance of a large dynamo machine would be, from laboratory experiments made upon a model of a very small fraction of its dimensions. As a proof of the practical utility of such methods, the lecturer stated that by

laboratory experiments he had succeeded in greatly increasing the capacity of the Edison machines, without increasing their cost, and with a small increase of their percentage of efficiency, remarkably high as that efficiency already was.

The electric properties of the electric arc were experimentally illustrated; in particular it was shown that the difference of potential between the carbons was nearly independent of the current.

When a current of electricity passed through a continuous conductor, it encountered resistance, and heat was generated, as shown by Joule, at a rate represented by the resistance multiplied by the square of the current. If the current was sufficiently great, heat would be generated at such a rate that the conductor would become incandescent and radiate light. Attempts had been made to use platinum and platinum iridium as the incandescent conductor. But these bodies were too expensive for general use, and besides that, refractory though they were, they were not refractory enough to stand the high temperature required for incandescent lighting, which should be economical of power. Commercial success was not realised until very thin and very uniform threads or filaments of carbon were produced and enclosed in reservoirs of glass, from which the air was exhausted to the utmost possible limit. Such were the lamps made by Mr. Edison with which the institution was temporarily lighted. The electrical properties of such a lamp were examined, and in particular it was shown that its efficiency increased and its resistance diminished with increase of current.

The building was lighted by about 230 lamps, each giving 16 candles' light, produced each by 75 watts of power developed in the lamp. To produce the same 16 candles' light in ordinary good flat-flame gas-burners, would require between seven and eight cubic feet of gas per hour, contributing heat to the atmosphere at the rate of 3,400,000 ft. lbs. per hour, equivalent to 1,250 watts, or nearly seventeen times as much heat as the incandescence lamp of equal power.

At the present time, lighting by electricity in London must cost something more than lighting by gas. What were the prospects of reduction of this cost? Beginning with the engine and boiler, the electrician had no right to look forward to any marked and exceptional advance in their economy. Next came the dynamo, the best of these were so good, that there was little room for economy in the conversion of mechanical into electrical energy; but the prime cost of the dynamo machine was sure to be greatly reduced. Hope of considerably increased economy must be mainly based upon probable improvements in the incandescence lamp, and to this the greatest attention ought to be directed. It had been shown that marked economy of power could be obtained by working the lamps at high-pressure, but then they soon broke down. In ordinary practice, from 140 to 200 candles were obtained from 1 H. P., developed in the lamps, but for a short time he had seen over 1,000 candles per H. P. from incandescence lamps. The problem, then, was so to improve the lamp in details, that it would last a reasonable time when pressed to that degree of efficiency. There was no theoretical bar to such improvements, and it must be remembered that incandescence lamps had only been articles of commerce for about three years, and already much had been done. If such an improvement were realised, it would mean that it would be possible to get five times as much light for a sovereign as could be done now. At present electric lighting would succeed commercially where other considerations than cost had weight. Improvements in the lamps were certain, and there was a probability that these improvements might go so far as to reduce the cost to one-fifth of what it now was. He left the meeting to judge whether or not it was probable, nay, almost certain, that lighting by electricity was to be the lighting of the future.

The fifth lecture of the series will be delivered on Thursday, the 19th of April, by Professor F. A. Abel, C.B., F.R.S., Hon. M. Inst. C.E., on "Electricity applied to Explosive Purposes."

The Royal Society, Edinburgh.—The ninth ordinary meeting of the Royal Society of Edinburgh in the current session took place last Monday week. In a communication "On some Laboratory arrangements," Dr. Gibson exhibited and explained a new filtering apparatus, and also an arrangement for the better preservation of sulphuretted hydrogen in water. Of the first, Professor Crum Brown said that experience of its working in the laboratory enabled him to state that it was an apparatus of first-class importance as making Bunsen's method of filtration applicable to almost every case. The second arrangement was, he said, also of considerable value. Professor Tait stated that the result of experiments made by himself "On the Thermo-electric Position of Pure Cobalt" was to show that cobalt occupied a position or line on the electric diagram very much below that of iron, but very nearly parallel to it—a result which he viewed as one of great value in his thermo-electric inquiry. Professor George Forbes gave a summary of a paper on the "Transmission of Power by Alternate Currents," in which he claimed that experiments made by him had negatived the objection that alternate currents could not transmit motor power at a distance. His experiments showed that alternate currents could transmit a perfect synchronism, and this discovery he regarded as opening out a much greater future for alternate currents than was thought possible a short time ago.

REVIEWS.

*The Electric Light and the Lamps, Carbons, and Illuminative Bodies employed in its Production.** By Dr. ALFRED VON URBANITZKY. Vienna, Pesth, and Leipzig: A. Hartleben.

THE author of this volume in his preface refers to the rivalry which exists between the electric light and coal-gas. Like Hefner von Alteneck he is disposed to consider it as an advantage of the electric light that it occasions a twofold intensity of gas-lighting to be realised as compared with the old standards. This view cannot be altogether accepted, since no improvements in the construction of burners can remove the greatest objections to gas—to wit, the unsteadiness of the flame, the injurious character of the products of combustion, the risk of explosion, and the great heat produced in the upper part of rooms.

The differences of opinion among the advocates of the electric light are naturally referred to. It appears that a work published last year in Paris enumerated no fewer than six hundred French patents for improved constructions of lamps, and, according to the author, the number of such devices patented in all countries now exceeds a thousand. Truly, among so many inventions, to separate the wheat from the chaff is no easy task. The author, however, proposes a classification which, if not free from objections, will at any rate facilitate a comparison of the various systems, and may be provisionally accepted. To this arrangement we shall presently return.

In the first chapter we find the theory of the "glow" or incandescence light, which appears whenever electricity is converted into heat, as was observed shortly after the discovery of the voltaic battery. The author refers to Joule as having made the first accurate investigations on this subject, and as having established the law that the quantity of heat evolved in a given unit of time is proportional to the conduction-resistance of the wire and to the square of strength of the current. The strength of the current, again, according to Ohm's law, is directly proportionate to the electromotive force, and inversely as the resistance of the circuit. Hence it appears that the intensity of a galvanic current is alike in all parts of the conduction, and that so long as the intensity of the current remains unchanged the quantity of heat produced depends on the resistance of the conductor. Hence if the resistance varies in different parts of the conduction the greatest quantity of heat will be produced where there exists the greatest resistance. The resistance must consequently reach its maximum in the lamps, and be as low as possible in other parts of the circuit. The communication of heat from the lamp to neighbouring objects should also be minimised. Hence it is preferable to exhaust the glass-globes of "glow" lamps instead of filling them with hydro-carbons, which conduct heat much better than a so-called vacuum.

In chapter ii. Dr. von Urbanitzky gives the history and the theory of the voltaic arc. He shows here that the intensity of the current required for the production of the arc cannot be obtained by an increase in the size of the plates, but in their number, or when the source of the current is a dynamo machine in the number of the coils of wire on the keeper which pass a magnetic field in a given time. Several estimates are quoted for the resistance and for the luminous power of the arc. Siemens gives the former = 1 Siemens unit; Schellen, = 30 to 40; Hagenbach, = 4.75. The luminous power of an arc of 3 millimetres is given as equal to 874 normal candles.

Concerning the temperature of the arc, the author points out that though the positive carbon may reach the heat of $3,900^{\circ}\text{C}$, yet the heated surface is so small that an arc light gives off only 1-100th part of the heat produced by the number of argand burners required to throw out the same quantity of light.

The author next treats of the subdivision of the electric light, one of the most important practical questions which here arise. The problem was first solved in 1876 by Paul Jablochhoff, who contrived to introduce a considerable number of his "candles" in one circuit. Since then, two other methods have been devised, the one depending upon a special construction of the machine, and the other by rami-

fications in the conduction. Each of these methods admits of two modifications: the machine may be so arranged as to have several perfectly independent and respectively insulated circuits, or, which is preferable, the subdivision is effected by a method of coiling the wires proposed by Marcel Deprez. He provides the electro-magnets of the machine with two circuits in which the strength of current in the one depends on the strength of the current in the lamp circuit, that of the other remaining unchanged.

The subdivision of the light by ramifications in the conduction is also twofold in its nature, according as the lamps are introduced successively or parallel with each other.

In chapter iv. the author discusses lamps and illuminative bodies, which he arranges in the following five groups:—

1. Glow or incandescence lamps with imperfect conductivity. The light is obtained by the ignition of an imperfect conductor in an uninterrupted circuit.
2. Glow lamps with imperfect contact, the light appearing at the contact of two conductors.
3. Regulator lamps where the light is formed by the voltaic arc and the distance of the carbon-points is regulated in accordance with the strength of the current.
4. Electric candles. Here, also, the light is produced by the arc, but the carbons are fixed parallel with each other, and their respective distance from each other remains unchanged during the whole duration of combustion.
5. Lamps with carbons placed inclining towards each other.

The devices which fall under each of these heads are next described in detail, the more important ones being represented by figures and diagrams. Thus, of the first class we have an account of the glow light of Edison, the imperfect conductor being made of bamboo fibre; the glow light of Swan, that of Maxim, of Lane-Fox, of Siemens & Co., of Boehm, and of Diehl. The lamps of Greiner and Friedrich, of Müller, Cruto and Pulu, and the recent platinum-wire lamp of Edison are merely mentioned. The methods of exhausting the glass globes on receivers for lamps of this class are described at some length.

Among the glow lamps of the second class, i.e., with imperfect contact, figure those of Reynier, Marcus, Werdermann, of Napoli, of Brougham, Ducretet, Hauck, and Joel. In this class it is remarked that a number of minute arcs are formed between the inequalities of the electrodes.

The first attempt at a regulator arc lamp with automatic movement appears to have been due to Thomas Wright in 1845, but his arrangement was not adopted. Leon Foucault in France, and Staite and Petrie in England, seem to have simultaneously taken up the idea of employing the current itself for regulating the carbon points. Other improvements have since been proposed by Archereau, Le Molt, Jaspar, Serrin, Lacassagne and Thiers, Way, Harrison, Dr. W. Siemens, and more recently by Reynier, Lontin, Mersanne, Fontaine, and Hefner von Alteneck. Many hundred lamps of such constructions are now in successful operation. Particular attention is given by the author to the lamps of Serrin, Jaspar, Gaffie, Crompton, Bürgin, and Sedlacek-Wikulill; the centrifugal-regulator lamp, that of Solignac, which is pronounced by Du Moncel very satisfactory; the horizontal lamp of Siemens, that of Fontaine, of Gramme, the Weston-Maehring, the Brush, the Edison regulator, the Gérard, the Schulze, the Tschikdeff; the differential ring-lamp of Schuckert, the differential lamp of Siemens and Halske, the lamps of Piette and Křížik; the regulator of Schwerd-Scharnweber, the Gülcher, and the Brockie.

Under the fourth group the author describes the electric candles of Jablochhoff and of Jamin, and makes passing mention of those of Siemens and Halske, Debrun, Solignac, and Andrew, all with parallel carbons.

Lastly we come to the arc lights with inclined carbons, as devised by Rapiéff, Gérard, the soleil lamps of Clerc, and the candle of Heinrichs.

A brief concluding chapter treats of carbons for arc lamps and their preparation.

This volume will be found a perfect encyclopædia of electric lamps of all known kinds, and as such will be of great utility to those who wish either to apply or to improve this method of illumination.

There are 89 carefully and correctly drawn figures. The only defect that we note is the absence of references to the original patents of the inventors.

* Das Elektrische Licht und die hierzu angewendeten Lampen, Kohlen, und Beleuchtungskörper.

THE MEASUREMENT OF ELECTRICITY.*

By JAMES N. SHOOLBRED, B.A.

THE measurement of all physical quantities rests upon three fundamental units—those of length, of mass, and of time. All other units can be derived from these.

In this country the fundamental units generally (though not always) used are:—Length, one foot (one-third of a yard); mass, one avoirdupois pound; time, one second of mean solar time.

In France, where the metrical system is in use, the fundamental units are:—Length, one mètre (supposed to be one four hundred thousandth of the earth's meridian); mass, one gramme; time, one second.

In each system, however, respectively, the above units are not always strictly adhered to. Thus, in the former, yards, grains, minutes, or hours may be substituted; and in the latter centimètres, millimètres, kilogrammes, or minutes might be used, according as most convenient for the dimensions of the quantities to be expressed. In dealing with precise measurements of physical quantities, and the comparison between them, this, of course, causes much confusion, while the great advantage of some common system of units for international communication has been speedily recognised. A variety of suggestions and attempts were made to remedy this; the most important of them being those of Professor Weber (of Germany), of Sir William Thomson, and of Mr. Latimer Clark.

The question was not, however, taken up practically till 1871, when the British Association for the Advancement of Science, at the instance of Sir William Thomson, referred it to a committee on "Electrical Standards." The labour of the committee was long and tedious, and extended till 1873. Among its members were Sir William Thomson (chairman), Dr. C. W. Siemens, Sir F. Bramwell, Dr. Joule, Mr. Latimer Clark, and Professors Carey Foster, Fleeming Jenkin, Everett, &c., &c., and also such distinguished electricians, now deceased, as Sir C. Wheatstone, Clerk Maxwell, and others.

The advantages offered by the metrical system for calculation, as well as from its already extended use, led to its selection by the committee as the basis of the units. But the centimètre was adopted, in preference to the mètre, as the unit of length, as being a more convenient dimension in general calculation, and also—since the cubic centimètre represented the volume of a gramme of water—by selecting the centimètre, the density of water became unity, which was a further advantage.

The fundamental units chosen were:—length, centimètre; mass, gramme; and time, second; and the name of the C.G.S. system given to it.

Under this distinction, this system, together with that of the "practical" units for electrical measurements (described further on) received, in 1881, the sanction of the International Congress of Electricians at Paris; and these systems are now being generally adopted into general use.

As with the use of a scale, common to all quantities, both very large and also very small numbers must often be represented, it is advocated in the C.G.S. system to express each number as the product of two factors, one of them being a power of 10; and also to effect this in such a way that the exponent of the power of 10 shall be the characteristic of the logarithm of the number. Thus 1,280,000 would be written as 1.28×10^6 , and .000128 as 1.28×10^{-4} .

The following table contains some of the units based upon the C.G.S. system:—

C.G.S. UNITS OF MEASUREMENT.

FUNDAMENTAL UNITS.

Length, one centimètre; mass, one gramme; time, one second.

DERIVED UNITS.

Mechanical.

Velocity.....Unit length in unit time:

Centimètre
Second.

Acceleration.....Rate of increase of velocity per second: In gravitation measure = g . g , in latitude of London, = 981 C.G.S. units.

Momentum Momentum of one gramme with a velocity of one centimètre per second.

Force or } *Dyne* Force which, acting upon one gramme for a second, generates a velocity of one centimètre per second.

Power } Amount of work done by one dyne working through one centimètre of distance.

Work—*Erg* Amount of work done by one dyne working through one centimètre of distance.

Electro-magnetic.

Magnetic pole A pole which, at one centimètre distant from a similar pole, gives the force of one dyne.

Magnetic field The intensity of a field which acts on unit magnetic pole with the force of one dyne.

Current.....A current flowing along one centimètre of a circuit in form of a circular arc, of one centimètre radius; and exerting a force of one dyne on a unit pole placed at the centre.

Quantity The quantity conveyed by unit current in one second.

Potential } The force required for the transference of +
or } electricity, at the rate of one erg of work per
Electromotive force } unit of electricity.

Resistance A resistance such that, with unit of difference of potential between the ends of conductor, one unit of current is conveyed along it.

N.B.—The estimation of resistance actually resolves itself into a

question of velocity $\frac{\text{Length}}{\text{Time}}$.

Some of the above C.G.S. electro-magnetic units being found to be inconveniently large, and others to be far too small, the following "practical" units, for general use, have been deduced from them. As already stated, they received, in 1881, the sanction of the International Congress of Electricians, and they are now being universally adopted.

"PRACTICAL" ELECTRICAL UNITS.

The *Ohm* (10^9 C.G.S. units of resistance), as the unit of resistance, is that of a column of mercury having one square millimètre of section, and of a length hereafter to be determined by a commission specially appointed for the purpose.

Note.—The length is supposed, however, to be between 104 and 105 centimètres.

The *Volt* (10^8 C.G.S. units of electromotive force), as the unit of electromotive force.

Note.—This corresponds nearly to that of a Daniell's cell.

The *Ampère* (10^{-1} C.G.S. units of current), as the unit of current; which is the current produced by one volt through one ohm.

The *Coulomb* (10^{-1} C.G.S. units of quantity), as the unit of quantity of electricity; which is defined by the condition that an ampère yields one coulomb per second.

The *Farad* (10^{-9} C.G.S. units of capacity), as the unit of capacity; which is such that one coulomb in a farad shall give one volt.

Or, to quote the words of Sir Wm. Thomson (the chairman of the British Association Committee which settled the C.G.S. system of units above referred to), when explaining the practical units to the Congress:—"The volt acting through an ohm gives a current of one ampère, that is to say, one coulomb per second; and the farad is the capacity of a condenser, which holds one coulomb, when the difference of potential of its two plates is one volt."

The following were also suggested by Dr. C. W. Siemens, in his inaugural presidential address at the British Association meeting, 1882, to be added to the above units:—

The *Watt* (10^7 C.G.S. units of power), as the unit of power; being the power conveyed by a current of one ampère in, one second through a conductor whose ends differ in potential by one volt.

The *Joule* (10^7 C.G.S. units of work), as the unit of work or heat, being the heat generated by a watt in a second.

The evaluation of the electrical energy of a supply depends upon the exact measurement of two factors—the amount of the supply and the pressure under which it is given; or, in other words, the quantity of the current and the electromotive force.

The product of the current expended, in ampère seconds, or of this amount of quantity expended to coulombs, by the electrical pressure of the same, expressed in volts, gives the therefore electrical energy expended, or the power of the supply.

The electrical energy is, therefore, represented by the product of volts $\times$ ampères $\times$ time; or by the product of volts $\times$ coulombs; or, expressed algebraically, $W = E C t = E Q$.

The following are the equivalent expressions for the same amount of power, only expressed in other terms, some of which may, perhaps, be more familiar:—

Rate of Expending Energy.

$$1 \text{ volt-ampère} = \begin{cases} 10^7 \text{ ergs per second.} \\ 1 \text{ watt.} \\ 1.35 \text{ foot-pounds per second.} \\ 3.3 \text{ kilogrammètres per second.} \\ 1.35 \text{ force-cheval (French horse-power).} \\ 1.35 \text{ horse-power.} \end{cases}$$

The Board of Trade suggests in the Provisional Orders for the supply of electricity, now pending, that the unit of price to be charged should be based on "the energy contained in a current of 1,000 ampères flowing under an electromotive force of one volt during one hour;" or, in other words, the unit might be put as 1,000 volt-ampère hours. The ampère-hour is another way of saying 3,600 coulombs of quantity of electricity supplied. It may also be of interest to state in other and perhaps more conventional terms the equivalent of the amount of work implied in the above unit.

Work Done, or Energy Expended.

$$1,000 \text{ volt-ampère-hours} = \begin{cases} 10^{10} \text{ erg hours.} \\ 3,600,000 \text{ volt coulombs.} \\ 3,600,000 \text{ joules.} \\ 1,000 \text{ watt's hours.} \\ 2,645,000 \text{ foot-pounds.} \\ 366,840 \text{ kilogrammètres.} \\ 1.35 \text{ force-cheval-heures.} \\ 1.34 \text{ horse-power-hours.} \end{cases}$$

Put in terms more in accordance with actual practice, the above unit might mean the supply for one hour of a current of 10 ampères with an electromotive force of 100 volts, or of a 5-ampère current with an E.M.F. of 200 volts; or again, a 10-ampère current at 200 volts for only half-an-hour, and so on, provided that the product of the three factors is always 1,000.

To arrive at a due evaluation of the supply of electrical energy, it is evident that the measurement of each of these two factors (in volts and ampères respectively), should be effected either separately or combined; and also that a continuous and cumulative record should be kept of the supply as it proceeds.

Many instruments exist for the measurement of the above elements,

* Abstract of Paper read before the Society of Arts, April 4th, 1883.

at any particular time, but without any means of continuously recording such measurements. These evidently, except under certain conditions, cannot comply with the commercial conditions required for ascertaining the amount of supply. It is only, therefore, instruments furnished with means of continuously integrating, or recording the successive progressions of the supply, or instruments to which such recording apparatus can readily be attached, that come properly within the scope of this paper.

To measure with completeness, for commercial purposes, a supply of electricity will entail, therefore, a continuous record of each of the two elements just referred to, current and pressure, either separately or combined. In the supply of towns, however, the question for the consumer may, and will most probably, be much simplified, by causing one of these elements, that of pressure, to remain constant; since it is very likely that a constant standard pressure of supply will be fixed by the Government in granting the several provisional orders. If so, it then becomes the duty of the suppliers to keep up to that pressure under penalty; and instruments for recording such pressure will have to be installed where required, and placed under proper supervision.

For the customer, however, it will then generally suffice to have an exact record of the quantity only of his individual consumption of electric supply.

It has been thought advisable to precede the description of the recording or registering instrument, which alone are "meters" in the commonly accepted sense of the word, by an enumeration of some of those non-recording instruments which are in more general use, since they suffice for present exigencies. This short descriptive enumeration is even almost necessary, since most of these instruments, by the addition of some recording apparatus, or appliance, by which the element of time can be integrated, may be made to enter into the class of registering meters. Indeed, some of them already possess their representative in this second class, or else have given rise to some modification, which has complied with the requirements in the latter case.

Thus, any current or ampère measurer may be converted into a record of quantity, or a coulomb-meter, by the integration of the time during which the current has flowed, and, similarly, any power of volt-ampère measurer may become a register of work done by means of the addition of the elements of time. Again, volt or pressure measurers will always be required in any case where a check is required upon the actual difference of potentials, or electromotive force of the supply, and this may arise from a variety of causes.

Mr. Shoolbred here described the following non-registering instruments: Siemens' electro-dynamometer, Obach's tangent galvanometer, Cardew's low-resistance galvanometer, and Ayrton and Perry's am-meter, all of which are familiar to the readers of the ELECTRICAL REVIEW.

Sir William Thomson's *Current Galvanometer*.—This instrument, together with his fellow one, for the measurement of the difference of potential have been termed "graded galvanometers." They are designed so as to permit of a very wide range being obtained with each respectively; this being effected by varying the intensity of the magnetic field in a known ratio, and comparing with it the unknown current.

The present instrument consists essentially of two parts; 1st, a coil of thick wire, through which the current to be measured is allowed to pass, it being fixed upright at the end of a wooden platform, with about one-half only of the coil projecting above it; and, 2nd, of a "magnetometer." This last consists of four short steel magnets (constituting the "needle") mounted in a frame on a vertical axis, with a long aluminum pointer attached, and inclosed in a quadrant-shaped box, with a glass cover, and a silvered glass mirror bottom (in order to counteract any effect of parallax while reading the scale of tangents, to which the instrument is graduated).

In order to increase the directive force of the needle, when required, a semicircular permanent magnet of hard steel, and of known intensity, may be fixed upright on two arms projecting from the magnetometer, behind the apex of the quadrant. The magnet stands over the needle, with its magnetic axis in the horizontal plane through that of the needle.

The magnetometer is made to slide along a groove in the wooden platform in front of the fixed coil, and in direction at right angles to it, the axis of the magnet and also of the needle (when at rest) being parallel to that of the coil; while the aluminum pointer, when at zero, which is the centre of the scale, lies in direction with the groove, or at right angles to the coil.

The range of sensibility obtained by varying the extreme distance along the groove of the magnetometer from the coil is about fifty-fold; while by removing the magnet, and leaving the needle under the influence of the earth's force alone, a further sensibility of fifty times greater can be obtained.

Mr. Shoolbred then turned his attention to pressure measurers, and said that Sir William Thomson's "potential" galvanometer differs only from his "current" instrument, already described, in the use of a thin wire coil (of German silver of about 6,000 ohms resistance), instead of a thick wire coil, and in the change in the connections to suit the present object.

The lecturer also made mention of Siemens' torsion galvanometer and Ayrton and Perry's volt-meter. He then described Ayrton and Perry's power-meter, which consists of a thick wire coil through which the main current passes, and of a fine wire coil on a shunt which is suspended within it. The axes of the two coils are parallel, and the passage of a current tends to deflect the suspended one. Since the thick wire coil measures the intensity of the current, and the thin wire one its electromotive force, and as the deflection of the latter is the product of the two, therefore the amount of that deflection is the measure of the power, or energy, of the current.

Modifications of this instrument, with or without a commutator, or with a wheel and pinion arrangement, are also made.

Siemens' *Watt-meter*.—This instrument, said Mr. Shoolbred, is constructed on the same principle as the electro-dynamometer. The

two coils are, however, kept distinct from one another, with separate terminals to each. The fixed one of thin wire, on a shunt, measures the electromotive force; while the movable one has the main current passing through it. The resulting position of the latter coil is due directly to the intensities of the two currents—that is, to the power developed. This product, of volts $\times$ ampères, is watts; hence the name of the instrument. The angle of torsion of the index-pointer gives the watts directly, and without the intervention of a table.

The instruments next spoken of were resistance measurers, and although, said the lecturer, measurements of this class are generally carried out by means of a galvanometer, a set of resistance coils, and a Wheatstone bridge (therewith balancing the unknown resistance by means of one of a known amount), yet amongst the instruments exhibited is the following one. It is intimately connected with some of those already described, and its internal arrangements are based upon one of the fundamental laws of electricity, that of Ohm which

states that resistance = $\frac{\text{E.M.F.}}{\text{current}}$.

Ayrton and Perry's *Ohm-meter* consists of two coils: a thick wire one for the main current, and a thick wire one on a shunt for the electromotive force. Both are fixed with their axes at right angles to each other. A needle is acted upon by the currents flowing through each, and as these are at right angles to each other, the

resulting deflection represents the ratio $\frac{\text{E.M.F.}}{\text{current}}$ i.e., resistance;

while in the power-meter the deflection is caused by the product of current $\times$ E.M.F.

In all these different instruments, devised by Ayrton and Perry, the deflections are caused, by duly proportioning the parts, to be directly proportional to the measurements sought for in each case.

(To be continued.)

TIHON AND RÉZARD'S ELECTRIC LAMP.

MESSRS. TIHON & RÉZARD have devised an electric lamp, for which they claim the simplicity of the Jablochhoff candle and the steadiness of the *lampe-soleil*. A writer in *La Lumière Electrique* describes it as follows:

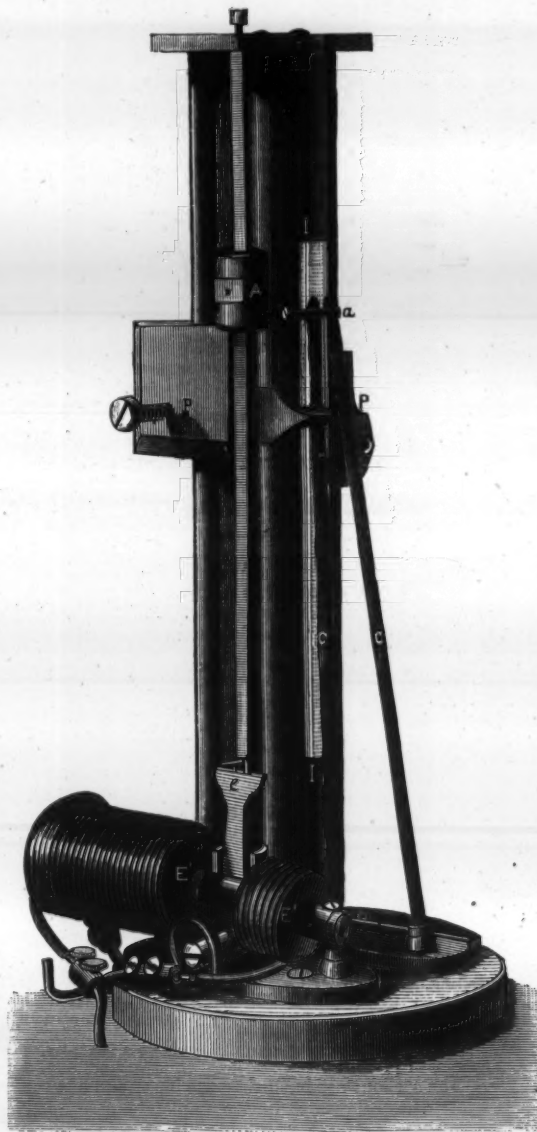
It consists essentially of two long carbons, *c* and *c*, resting diagonally against a plate of calcined magnesia, *I I*, provided upon the sides with two channels against which the carbons lean, and these carbons are inclined from each side by two sockets insulated from each other. The plate of magnesia is riveted upon a vertical bronze standard, which serves to support the system and which bears on the right and left side of the magnesia plate, two vertical rods, along which slide two weights, *P P*, formed at the ends into a sort of metal hook which rests upon the carbons about two centimetres from its free extremity and conducts the current to it. In this way the resistance of the carbons is reduced to the length of the portion between the magnesia plate and the hook which rests upon it, and as this hook is lowered under the influence of the weight, *P*, gradually as the carbon burns, the resistance of the carbons remains always the same, that is to say, that of a length of two centimetres and, moreover, the contact with the magnesia is always maintained under the same degree of pressure.

When the carbons are burned to the lower end of the magnesia plate, the weights, *P*, have completely descended and rest upon a commutator which, in its turn, transfers the current into another lamp.

In order to light the lamp automatically, Messrs. Tihon and Rézard employ a small transverse carbon, *a*, supported by a metallic body, *A*, fitted upon a square shaft turning upon its axis, and furnished at *e* with a tappet. This tappet is placed between the two teeth of a fork which is joined to the armature of an electro-magnetic system, *E E'*, through which the current which feeds the lamp passes. This system consists of two electro-magnets of which the smallest takes the part of an armature. When not in use, the weight of the armature, *E'*, makes the shaft turn so that the small carbon, *a*, rests upon the two carbons, *c*. But, as soon as the current passes, the electro-magnet, *E*, becoming magnetised, *E'* is attracted, the fork, *e*, makes the shaft turn from right to left, and *a*, leaving the carbons, produces the light. The arc is now established and passes over the magnesia as in the *lampe-soleil*, producing a considerable heat which maintains a uniform conductivity in the air around the carbon points, and causing at the same time a similar effect to that in the Drummond light. As the mass, *A*, descends at the same time as the block, *P*, which serves to arrest it, the lighter, *a*, is always level with the points of the carbons.

If, therefore, the lamp is extinguished, the fall of E' immediately replaces a at the right point for automatically re-lighting as soon as the current passes again.

This system, as we have already said, acts in a very satisfactory manner; unfortunately it can only be applied to side lights, for the support of the apparatus hides the luminous point behind the carbons.



The inventors of this lamp claim that it can be constructed very cheaply. With the supports made of iron and mounted upon plates of glass, they will not cost more than five francs, and they have also the advantage of slower combustion of the carbons, since these, only receiving the current near the point, only redden to this part, and do not suffer a useless lateral consumption. On the other hand, the refractory matter, becoming itself incandescent under the influence of the heat, reinforces the light of the arc and increases, to a certain extent, the luminous power developed, at the same time maintaining its steadiness. As this light is rich in yellow rays, it gives a warm and agreeable tint to illuminated objects.

Lastly, Messrs. Tihon & Rézard observe that with their system they can give any desired intensity to the arc, for the magnesia plate may be cast with the projecting part which separates the two channels more or less narrow, which elongates or shortens the arc, and consequently increases or decreases its resistance. The magnesia plates are, besides, inexpensive; they are manufactured in a mould and agglomerated under the influence of simple pressure, without

any liquid. They may be made commercially at a price of one or two centimes each, and by their use, two carbons twenty centimetres long and four millimetres in diameter, will last three hours, whilst in candles they do not quite last two hours.

According to experiments made by Messrs. Tihon and Rézard with a De Méritens alternating current machine, it seems that with an electromotive force of 60 volts and a current of 10 ampères, three lights could be obtained producing a lighting power of about 80 carcels. The resistance of each lamp would be 1.5 ohms, and that of the machine and circuit about 1.15 ohms.

As it is, this lamp is certainly interesting, and further experiments will be useful.

THEORY OF THE ACTION OF THE CARBON MICROPHONE—WHAT IS IT?

(A COMMUNICATION.)

A CAREFUL examination of the opinions of scientific men given in the telephone cases—before Lord McLaren in Edinburgh and before Mr. Justice Fry in London—leads me to the conclusion that scientific men, at least those whose opinions I shall quote, are not agreed as to what is the action of the carbon microphone.

In the Edinburgh case, Sir Frederick Bramwell said “the variations of the currents are effected so as to produce with remarkable fidelity the varied changes which occur, according as the carbon is compressed or relieved from compression by the gentle impacts of the air set in motion by the voice.” “The most prominent quality of carbon is its capability, under the most minute differences of pressure, to enormously increase or decrease the resistances of the circuit.” “That the varying pressure of the black tension-regulator (Edison’s) is sufficient to cause a change in the conducting power.” Sir Frederick also said “he could not believe that the resistance was varied by a jolting motion; could not conceive a jolting motion producing variation and difference of pressure, and such an instrument could not be relied on, and therefore would be practically useless.”

Sir William Thomson, in the same case, said: “The function of the carbon is to give rise to diminished resistance by pressure;” it possesses the quality of, under slight degrees of pressure, decreasing the resistance to the passage of the electric current;” and, also, “the jolting motion would be a make-and-break, and the articulate sounds would be impaired.” “There can be no virtue in a speaking telephone having a jolting motion.” “Delicacy of contact is a virtue; looseness of contact is a vice.” “Looseness of contact is a great virtue in Hughes’ microphone;” and “the elements which work advantages in Hughes’ are detrimental to the good working of the articulating instrument.”

Mr. Falconer King said: “There would be no advantage in having a jolting motion; the jolting motion would break the circuit, and be a defect in the speaking telephone,” and “you must have pressure and partially conducting substances.”

Professor Fleeming Jenkin said, “the pressure of the carbons is what favours the transmission of sound.”

All the above-named scientific men agree that variations of a current passing through a carbon microphone are produced by pressure of the carbons against one another, and they also agree that a jolting motion could not be relied upon to reproduce articulate speech.

Mr. Conrad Cooke said, “The first and most striking principle of Hughes’ microphone is a shaking and variable contact between the two parts constituting the microphone.” “The shaking and variable contact is produced by the movable portion being affected by sound.” “Under Hughes’ system, where gas carbon was used, the instruments could not possibly work upon the principle of pressure.” “I am satisfied that it is not pressure in the sense of producing a change of resistance.” “I do not think pressure has anything to do with it.”

Professor Blyth said: “The Hughes’ microphone depends essentially upon the looseness or delicacy of contact.” “I have heard articulate speech with such an instrument without a diaphragm.” “There is no doubt that to a

certain extent there must be a change in the number of points of surface contact when the pencil is moved." "The action of the Hughes microphone depends more or less upon the looseness or delicacy of the contact and upon the changes in the number of points of surface contact when the pencil is moved."

Mr. Oliver Heaviside, in *The Electrician* of 10th February last, writes: "There should be no jolting or scraping." "Contacts, though light, should not be loose."

A writer, who signs "W. E. H.," in *The Electrician* of 24th February last, says: "The variation of current arises from a variation of conductivity between the electrodes, consequent upon the variation of the closeness or pressure of contact;" and also, "there must be a variation of pressure between the electrodes when the transmitter is in action."

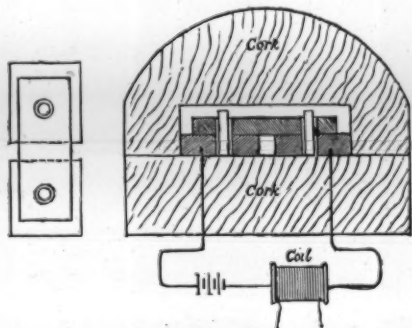


FIG. 1.

It seems, then, that some scientific men agree that variation of pressure is required to produce action in a microphone, and some of them admit that a microphone with loose contacts will transmit articulate speech, while others deny it, and some admit that a jolting or shaking motion of the parts of the microphone does not interfere with articulate speech, while others say such motion would break the circuit, and cannot be relied on.

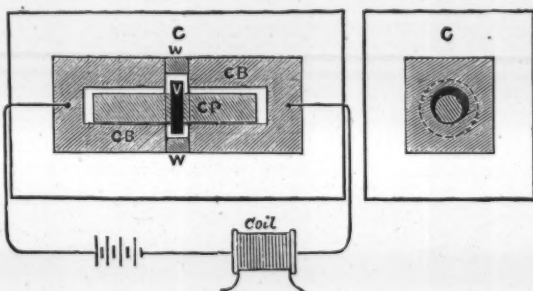


FIG. 2.

I will now describe two microphones in which there is a shaking or jolting motion, and loose contacts, and no variation of pressure of the carbons against one another, and both of these microphones when used with an induction coil and battery give most excellent articulation. One of these microphones is made as follows: Two flat plates of carbon are secured to a block of cork, insulated from each other; into a hole of each carbon a pin of carbon fits loosely, projecting above the carbons; another flat piece of carbon, having two holes in it, bridges over the two lower carbons, being kept in its place by the pins of carbon which fit loosely in the holes in it, the bottom carbons being connected with the battery; a block of cork has a flat side of it cut out so as when secured to the lower cork the carbons will not come in contact with it, yet be close enough to it to keep the carbons from falling apart. The cork covering the carbons forms a dome.

Any good telephone receiver when used in connection with this microphone, reproduces articulate speech with remarkable distinctness, especially hissing sounds, and with a loud and full tone.

A description of this microphone was published in "*La*

Lumière Electrique," of 15th April, 1882, and a drawing thereof on 29th April of same year.

Another form of microphone is made as follows:—Two blocks of gas carbon, C, B, each about one and a-half inches long and one inch square, having each a circular hole one and a-quarter inch deep and half inch in diameter; these two blocks are embedded in a block of cork, C, about one quarter of an inch apart, these holes facing each other, each block forming a terminal of the battery and induction coil; a pencil of carbon, C, P, about three-eighths of an inch in diameter, and two inches long, having a ring of ebonite, V, fixed around its centre, is placed in the holes of the two fixed blocks; the ebonite ring fitting loosely in between the two blocks so as to prevent the pencil from touching the bottom of the holes in the blocks; the space between the blocks is closed with wax, W, to exclude the air, but not to touch the ring on the pencil. A block of cork fitting close to the carbon blocks on all sides is then firmly secured to the other block of cork. The microphone should lie horizontally or at a slight angle.

This microphone produces in any good telephone perfect articulation in a loud and full tone. In these microphones there is certainly "looseness and delicacy of contact," and there is "a jolting or shaking motion," and it does not seem possible that there can be any "pressure of one carbon against another."

I repeat the question I asked at the beginning of this communication, and hope that it may elicit from you, or some of our scientific men, an explanation of the theory of the action of this form of microphone.

W. C. Barney.

April 9th, 1883.

The Displacements and Deformations of Sparks by Electrostatic Actions.—By M. Aug. Righi.—Well-known experiments show that the electric discharge begins when the electric density at the electrodes has a sufficient value in proportion to the diameter of the balls, their nature, distances, &c. If we admit that the discharge is constituted by the emission of electrified particles it should begin upon that one of the two electrodes where the density is the greater, whence follows the explanation of many phenomena.

If we suppose that at a little distance from the place where the spark is formed there are other electrified bodies the particles ought to deviate from their track and diverge from bodies charged with the same electricity, and approximate to bodies charged with the contrary kind. The spark must follow the path of the first particles repelled, for in virtue of the heat evolved it offers the least resistance. The spark itself ought then to be deflected as if it were a body charged with electricity of the same kind as that of the electrode where the density prior to the discharge is greatest.

One of the methods in which I have verified facts of this kind is the following. We arrange perpendicularly, the one under the other, the two rods supporting the vertical charging-balls, and at an equal distance two parallel vertical plates kept always charged, the one + and the other — by a Holtz machine with auxiliary combs, the exciters of which are sufficiently far from each other that the sparks cannot strike. We observe easily that when the two plates are not charged the spark produced between the two stems by the discharge of a condenser (charged by another Holtz machine) is almost a vertical right line, if the balls are not too far distant. But if the plates are charged and if the balls are not identical in all respects, the spark becomes curved, approaching the one or the other plate. These changes of shape are very remarkable if we insert in the circuit of discharge a resistance such that the spark becomes yellow. It acquires then very curious forms, and at the same time it is observed to set out from lateral parts of the electrodes.

Let us suppose, for instance, that the two balls are identical in dimensions and nature, but that one of them, the negative, communicates with the ground. The density is then greater upon the positive ball, and the discharge must begin there. The spark is, in fact, displaced and distorted, as if it were a flexible body positively electrified. The same effect is obtained if both balls are isolated, but the diameter of the negative is greater than that of the positive.—*Comptes Rendus*.

TABLE SHOWING THE RELATIVE DIMENSIONS, LENGTHS, RESISTANCES, AND WEIGHTS OF PURE COPPER WIRE.

B.W.G.	DIAMETER.		AREA.		LENGTH AND WEIGHT.										LENGTH AND RESISTANCE.										RESISTANCE & WEIGHT.	
	Inch.	Milli- metres.	Circular Mils.	Square Inches.	Square Mills.	Pounds per foot.	Pounds per yard.	Pounds per 100 ft.	Yards per lb.	1,000 ft. per lb.	Miles per lb.	Feet per lb.	Yards per lb.	1,000 ft. per lb.	Miles per lb.	Ohms per foot.	Ohms per yard.	Ohms per 1,000 ft.	Ohms per mile.	Ohms per lb.	B.W.G. No.					
0000	1/4	11.3213	96616	101883	104425	0.22024	1.87772	623.984	3291.32	1.00270	0.00003533	19060.5	6555.5	1749715	3.7815	0.00000004	0.00110133	0.00004	0.00004	0.000000272	13457.5	0000				
000	3/16	10.75	13625	141862	9152	0.5676	1.64028	546.76	2888.89	1.32895	0.00003639	17497.15	5323.353	1749715	3.31355	0.000000122	0.001714566	0.071322	0.071322	0.00104329	8566.7	000				
00	1/8	9.518	11400	110411	71065	0.71065	2.13115	437.105	2307.22	1.62777	0.0000433	13688.04	4692.68	1368804	2.64255	0.000000149	0.00211467	0.1169	0.1169	0.00163533	6114.24	00				
0	3/32	8.6338	11560	100722	5373	0.89928	1.04784	349.928	1814.63	2.82773	0.0000473	11198.17	3723.733	1119817	2.12686	0.000000202	0.00267006	0.083002	0.083002	0.00203196	3915.48	0				
1	1/4	7.59	9900	90768	4508	1.0674	0.71065	274.35	1438.43	3.7676	0.0000519	8719.39	2967.19	871939	1.6518	0.000000170	0.0030311	0.1701	0.1701	0.00242109	2751.8	1				
2	5/32	7.2134	8655	803472	4087	1.2431	0.72433	244.151	1289.11	4.0938	0.0000568	7813.50	2604.50	781350	1.47373	0.000000179	0.0033397	0.1799	0.1799	0.00269422	1907.99	2				
3	3/16	6.5781	6781	625254	3780	1.4655	0.69174	203.058	1072.15	4.9217	0.0000619	6198.16	2165.026	619816	1.25971	0.000000138	0.0041167	0.1539	0.1539	0.00275782	1319.40	3				
4	1/4	6.0151	5944	544381	2970	1.71465	0.61435	171.465	903.333	5.8321	0.0000682	5487.107	1829.037	5487107	1.03223	0.000000124	0.0046735	0.12245	0.12245	0.0028256	940.844	4				
5	7/32	5.5879	4900	459013	2152	1.9624	0.54226	134.712	658.638	6.8165	0.0000765	4688.51	1592.536	468851	0.83575	0.000000106	0.0053961	0.10387	0.10387	0.0030062	687.91	5				
6	1/2	5.1561	4139	382355	1688	2.24742	0.47428	107.412	538.844	8.0165	0.0000865	3991.91	1330.636	399191	0.75045	0.000000090	0.0061518	0.08506	0.08506	0.0032682	497.96	6				
7	9/32	4.7719	3240	325169	1017	2.58976	0.40876	88.076	444.844	9.5818	0.0000981	3138.59	1046.190	313859	0.6443	0.000000074	0.0070542	0.07184	0.07184	0.0035483	387.82	7				
8	11/32	4.3991	2725	2721325	7374	2.98411	0.34233	74.11	435.135	10.962	0.0001113	2537.29	879.096	253729	0.54986	0.000000059	0.0081321	0.05917	0.05917	0.0038901	317.343	8				
9	1/2	4.0331	2160	217201	5168	3.4354	0.28305	62.364	330.089	12.388	0.0001268	2127.84	707.280	212784	0.46184	0.000000046	0.0091138	0.04618	0.04618	0.0042865	249.659	9				
10	13/32	3.6833	1746	174105	4006	3.9439	0.23062	54.354	286.59	13.88	0.0001445	1739.40	579.80	173940	0.39432	0.000000036	0.0101743	0.03943	0.03943	0.0046601	217.343	10				
11	1/2	3.3479	1440	141367	3296	4.5139	0.1877	43.380	239.122	15.913	0.0001691	1391.93	461.9706	139193	0.32191	0.000000028	0.0111387	0.03219	0.03219	0.0050865	189.659	11				
12	1/2	3.0271	1181	108313	2619	5.1594	0.14882	35.964	189.833	17.805	0.0001965	1150.91	383.636	115091	0.25776	0.000000022	0.0121060	0.02577	0.02577	0.0055665	169.802	12				
13	1/2	2.7125	963	907682	2137	5.8719	0.11957	27.319	144.245	19.646	0.0002268	877.252	291.473	877252	0.19578	0.000000017	0.0130719	0.01957	0.01957	0.0060625	141.392	13				
14	1/2	2.4083	818	760115	1686	6.6459	0.09706	20.853	110.168	21.423	0.0002609	677.338	222.446	677338	0.16338	0.000000013	0.0139404	0.01633	0.01633	0.0065665	121.863	14				
15	1/2	2.1159	683	610115	1386	7.4883	0.07676	15.692	89.853	23.267	0.0003009	507.175	167.306	507175	0.13615	0.000000010	0.0147914	0.01361	0.01361	0.007088	103.112	15				
16	1/2	1.8331	562	503181	1140	8.3972	0.05837	12.789	67.6276	25.192	0.0003484	409.276	136.4233	409276	0.11409	0.000000008	0.0156434	0.01140	0.01140	0.007638	83.732	16				
17	1/2	1.5583	451	42421	934	9.3795	0.04384	10.188	53.7955	27.303	0.0003989	323.871	108.6206	323871	0.09578	0.000000006	0.0165005	0.00957	0.00957	0.008235	67.804	17				
18	1/2	1.2831	350	32638	737	10.3795	0.03376	7.26796	38.3748	29.676	0.0004509	237.585	77.9233	237585	0.07859	0.000000005	0.0173563	0.00785	0.00785	0.008875	53.734	18				
19	1/2	1.0083	261	240854	537	11.3795	0.02432	5.3972	28.1957	31.590	0.0005068	179.879	56.9566	179879	0.06323	0.000000004	0.0181916	0.00632	0.00632	0.009366	44.4947	19				
20	1/2	0.8890	201	186511	420	12.3795	0.01745	4.0972	21.0815	33.676	0.0005666	149.3915	49.757166	1493915	0.051075	0.000000003	0.0190434	0.00510	0.00510	0.010273	35.2254	20				
21	1/2	0.7712	156	143045	318	13.3795	0.01245	3.0972	15.692	35.761	0.0006266	119.961	35.90243	119961	0.040015	0.000000002	0.0198916	0.00400	0.00400	0.011403	27.2754	21				
22	1/2	0.6535	121	110573	251	14.3795	0.00872	2.3312	12.5301	37.840	0.0006866	99.195	29.18466	99195	0.031389	0.000000001	0.0207373	0.00313	0.00313	0.012591	21.911	22				
23	1/2	0.5358	93	84068	204	15.3795	0.00607	1.7309	9.9892	39.950	0.0007466	80.357	24.18466	80357	0.023359	0.000000001	0.0215844	0.00233	0.00233	0.013782	17.44	23				
24	1/2	0.4181	71	65115	163	16.3795	0.00432	1.2659	7.3373	41.961	0.0008066	64.883	19.18466	64883	0.016389	0.000000001	0.0224318	0.00163	0.00163	0.014963	14.5579	24				
25	1/2	0.3004	54	50031	127	17.3795	0.00307	0.9072	5.5943	43.961	0.0008666	51.473	15.03336	51473	0.009443	0.000000001	0.0232819	0.00094	0.00094	0.016143	11.616	25				
26	1/2	0.1827	41	38043	102	18.3795	0.00207	0.6507	3.9072	45.961	0.0009266	40.961	11.46196	40961	0.007573	0.000000001	0.0241318	0.00075	0.00075	0.017282	9.295	26				
27	1/2	0.1651	32	28043	77	19.3795	0.00142	0.4916	2.9166	47.961	0.0009866	32.707	8.590243	32707	0.005953	0.000000001	0.0249819	0.00059	0.00059	0.018491	7.44	27				
28	1/2	0.1474	24	21043	59	20.3795	0.00107	0.3654	2.110	49.961	0.0010466	24.707	6.32843	24707	0.004513	0.000000001	0.0258319	0.00045	0.00045	0.019643	5.7724	28				
29	1/2	0.1297	19	16043	45	21.3795	0.00082	0.2711	1.5171	51.961	0.0011066	19.379	5.470	19379	0.003493	0.000000001	0.0266819	0.00034	0.00034	0.020791	4.6825	29				
30	1/2	0.1120	14	12043	34	22.3795	0.00067	0.2043	1.1943	53.961	0.0011666	14.961	4.64676	14961	0.002493	0.000000001	0.0275319	0.00024	0.00024	0.021943	3.7934	30				

PURE COPPER weighs 555 lbs. per cubic foot.
The Resistance of 1 mil. foot at 50° Fahr. is, according to Dr. Matthiessen, 1.02311 ohms. Upon these data the above Table has been calculated.

SHADED WIRES.—With a conductor of a definite length, made of Stranded Wire, the total weight is greater, and the Resistance less than is a similar length of Conductor with Wire not Stranded.

To convert—Inches to Millimetres multiply by 25.3994
Feet to Metres " " 3.2808
Yards to Metres " " 0.9144
Miles to Kilometres " " 1.60934
Pounds to Kilograms " " 0.45359

ENTERED AT STATIONERS' HALL.—(Copyright.)

PREPARED BY WALTER T. GLOVER & CO., ELECTRICAL WIRE AND CABLE MAKERS, 25, BOOTH STREET, MANCHESTER.
April 12th, 1888.

THE CRYSTAL PALACE ELECTRICAL
EXHIBITION.

AMONG the exhibitors at this Exhibition are the following:—

JOSEPH BOURNE & SON, ST. PANCAS STATION, EUSTON ROAD.—The celebrated stone insulators and battery cells of Messrs. Bourne, which are shown in the north nave, include several patented shapes, among them being the well-known Varley's double V and Z patterns. For the white stoneware of this firm is claimed all the merits of white porcelain, including colour, at considerably less cost.

THE CHALFONT ENDLESS TELEGRAPH PAPER COMPANY, GREAT SAFFRON HILL, E.C.—This company shows specimens of its rolls of telegraph paper for the Morse, Wheatstone, automatic, and other printing instruments; and, having in use patented machinery, the company has advantages over ordinary methods of hand-cutting, and is thus enabled to sell at a lower rate than is usually charged.

THE CRYSTAL PORCELAIN POTTERY COMPANY, LIMITED, ST. SWITHIN'S LANE, E.C., exhibits some fine specimens of its telegraphic and electrical insulators, accumulator rests, insulating tablets and slates.

H. & E. J. DALE, LITTLE BRITAIN AND LUDGATE HILL, E.C.—Various exhibits are shown by this firm, among them being small dynamo-electric machines for the production of small arc lights, and for small numbers of incandescent lamps; Dale's "granule" battery for incandescent lamps and experimental purposes; Dale's special "signal" battery for working on closed circuit, as made and used for electric signs, frictional machines, and electric bells.

J. DARLINGTON, COLEMAN STREET BUILDINGS, MOORGATE STREET, E.C.—On his stand Mr. Darlington has a model of Bornhardt's double-plate electric firing machine, and also of Bornhardt's double-plate machine, as used for blasting in mines, quarries, submarine works, &c. A single-plate machine is said to be capable of firing simultaneously any number of charges up to 20, while a double-plate machine can fire considerably more. In the measurement of electricity division, Mr. Darlington exhibits a spark scale, consisting of five discs, each disc having ten breaks, to show the passage of spark across five breaks in the circuit, representing the firing of five charges simultaneously. These discs, being connected together in the circuit, are stated to show the passage of the spark across fifty breaks, representing the simultaneous firing of fifty charges. Among the other exhibits of Mr. Darlington are samples of Bornhardt's electric fuses and the various appliances used in blasting.

WALTER T. GLOVER & CO., MANCHESTER.—Messrs. Glover & Co. exhibit in the north nave a large assortment of specimens of their well-known insulated wire and cables.

GÜLCHER'S ELECTRIC LIGHT AND POWER COMPANY (LIMITED), AND DEFRIES & SONS, HOUNSDITCH.—As we specially mentioned a few weeks since, these firms combine in one exhibit, which consists of 15 Gülcher arc lamps of different patterns, and about 600 Crookes' incandescent lamps, all worked off the same Gülcher low tension dynamo machines, shown with a series of electroliers of new design, manufactured by Messrs. Defries & Sons, and including all fittings likely to be required in private houses, theatres, and large halls. Naked conducting wires from the dynamo are exhibited to show the safety of the system. Crookes' lamp, it is stated, takes less power than any other invented up to the present time, and is capable of giving a strong light for a longer period without breaking. The lamps can run on the same Gülcher machine as arc lamps. The mediæval court is lighted from five central standards in cut crystal and polished brass, bearing 41 Crookes' lamps, which spring out of various tints of glass, designed for the lighting of large rooms, conservatories and summer gardens. Above is suspended a 42-light polished brass electrolier of ecclesiastical design, specially intended for church work, and lighted with Crookes' lamps in opal glass. The front of the French mediæval vestibule is covered by a great dome, consisting entirely of cut glass and of Moorish pattern, and beneath this is suspended a large electrolier of 60 lights, consisting of cut crystal and lighted by Crookes' lamps. The dome is illuminated by a Gülcher lamp of 2,300 candle-power. The whole of the crystal used at this Exhibition has been specially made by Messrs. Defries, with a view to

displaying to the utmost possible extent the effect of electric light on good crystal.

T. R. HARDING & SON, LEEDS.—Harding's patent counters and speed indicators, especially adapted for electric light machinery, are shown in various forms in the north nave.

GEO. JENNINGS, PALACE WHARF, STANGATE, S.E., shows his specialities in electric apparatus, automatic speaking tubes, "secret" burglar alarm contacts, the "vacuum" contacts, improved indicators, &c.

G. C. LEWIS & SON, LOWNDES TERRACE, KNIGHTS-BRIDGE, S.W., have a neatly laid-out stand in the north nave, with electric bells for domestic use, indicators, pushes and pulls, burglar alarm triggers, fire alarms, insulated wires, battery cells, &c. A prize medal was awarded this firm at the Exhibition last year.

WILLIAM REDDALL, SOUTH STREET, FINSBURY.—Mr. Reddall, architect, exhibits a patent box street curb for the conveyance of electric wires, especially through the streets of cities and towns. Its proposed position as a curb to the footways provides for the ready insertion, inspection, or removal of any length of wires, the effectual covering of the same, and communication with every house, at a cost in London a little beyond that of the ordinary granite curb.

HENRY ROBERT MEYER, LIVERPOOL.—Mr. Meyer's patent permanent way for electric conductors, or underground mains, which is also shown at the Aquarium Exhibition, and to which we previously referred, is exhibited at his stand in the north nave.

SANDERSON & CO., LEADENHALL HOUSE, LEADENHALL STREET, E.C., exhibit their patent solid copper tape lightning conductors, portable galvanometer for testing lightning conductors, and their telegraph instruments, electric bells, burglar alarms, &c.

JAMES STIFF & SONS, LONDON POTTERY, LAMBETH, S.E.—This firm, which was awarded a prize medal at the Paris Electrical Exhibition of 1881 for its manufactures, shows, in the north nave, porous cells, cylinders and plates of varying degrees of porosity to suit different batteries, vitrified battery-jars, and other electrical sundries in stoneware and porous ware.

WILLIAM ROBERT SYKES, KIRKWOOD ROAD, NUNHEAD, S.E.—Mr. Sykes, in the north nave, exhibits his combined electric lock and block system of signalling on railways. This invention was the first introduced and worked on any railway, forming the mechanical union between the lock and block, and the connection between three signalling points. The signals have been working for several years on several well-known railways, and wherever they have been in use it is said that no accident has occurred.

S. ALFRED VARLEY & CO., 2, HAMILTON ROAD, HIGHBURY PARK.—Dynamo-electric machines, including the original machine provisionally protected by Mr. Varley in 1866, are shown by this company in the north nave. In this machine is introduced "the fundamental principle of the dynamo." The principle, said to have been first discovered by Mr. Varley, "forms the basis of the economical production of electricity and magnetism for the transmission of force, the production of light, &c."

Royal Scottish Society of Arts.—A meeting of this Society was held on Monday night, at Edinburgh—Professor Swan, president, in the chair. There was submitted the report of the committee on Tate's electric valve-closing apparatus, which stated that this invention seemed admirably adapted for the purpose specially in view—viz., the immediate stoppage of machinery in the event of an accident, either to the machinery itself or to persons employed. The value and importance of an arrangement, the report proceeded, by which the actuating power in large mills can be rapidly controlled and brought to a stand, cannot be overestimated. The facility with which this can be accomplished from any part of the factory, however distant from the engine, by the easy and instant application of electricity in the mode proposed by Mr. Tate, appears to the committee to merit the highest commendation of the Society. [A full and illustrated description of this apparatus will be found in the ELECTRICAL REVIEW for October 21st, 1882.]

**ELECTRIC LIGHTING OF THE UNION
SOCIETY'S BUILDINGS AT OXFORD.**

THE whole of these large buildings, consisting of libraries, debating-hall, writing-room, offices, &c., accommodating over 1,000 members, are lighted with electric lights, fitted by the Pilsen-Joel and General Electric Light Company (Limited), of London, and apparently with great success.

During the last year's Electric Light Exhibition at the Crystal Palace a committee from the Union Society specially visited the Exhibition, with a view to adopting the electric light in the Union Society's buildings, and they were commissioned to report upon the best system for the purpose. The result of this visit was the selection of the Pilsen arc lamp for the large halls, as being the steadiest and free from noise, and the Swan incandescent lamps for the small rooms, &c.

The following description will give some idea of the extent of this interesting installation.

The debating-hall, whose area is 70 ft. by 40 ft., was previously lit with two sun-lights, each consisting of 49 gas-jets of eight candle-power each, giving a total light of 784 candles, at an elevation of 30 ft. These have been replaced by two Pilsen lamps, at the same elevation, each of 2,000 candle-power; 50 per cent. of this light is lost owing to the opal globes used to soften the light, so that the useful light given out is a total of 2,000 candles, or almost three times that given by the discarded gas.

The lamps are lowered for trimming and cleaning by a special arrangement of cords passing over drums fitted above the ceiling, and which are so arranged that the cable is pulled up simultaneously with the lamps, thus avoiding the disfiguring festoon usually employed. In the library, which is a handsome hall 50 ft. high by 30 ft. broad and 70 ft. long, are hung two Pilsen lamps, to replace a large gasalier of 54 jets and 10 single lights under the gallery. The lamps are suspended about 25 ft. from the floor, and their weight is counterbalanced by cast-iron counterweights, which are suspended by cords passing over drums fixed above the ceiling, over which the cable is made to pass automatically. Under the gallery are distributed nine incandescent lamps, each of 20 candle-power, to relieve the shadows cast by the gallery. These however are not required.

The Pilsen lamps are identical with those in the debating-hall, so that the total light given out is 2,180 candle-power, as compared with 64 gas-jets of 10 candle-power, or 640 candles. Since the electric light has been started in this room there is already a marked difference in the condition of the books, especially those near the roof, owing to the total absence in the electric light of those injurious elements which render gas so objectionable. The library walls have been decorated by old students of the University with paintings illustrating the Arthurian Legends, and these are now seen to much greater advantage than previously.

The next room in rotation is the writing-room, which used to be lighted by four gasaliers having a total number of 50 gas-jets, but by placing the electric lamps in more advantageous positions they light up the writing-tables more efficiently with 14 incandescent lamps of 20 candle-power each.

The smoking-room, which is immediately above the writing-room, is furnished with one Pilsen lamp and seven incandescent lamps, to replace one gasalier of 54 jets of eight candle-power and 10 single lights, so that the light is about doubled.

In the other rooms, entrance halls, staircases, &c., incandescent lamps are entirely used, and in most instances simply replace the gas-jets.

The incandescent lamps are joined up in multiple series of two, so that in case of one lamp short-circuiting, the other in the same series serves as a safety plug, and in practice this is found to be more to be depended upon than the ordinary lead fuses which are usually employed. Fusible plugs are, however, fitted on all the main branches.

The incandescent lamps are worked by a thick wire quantity machine, and the Pilsen lamps by a No. 6 Pilsen dynamo machine.

The generating power consists of a 12-H. P. nominal Crossley gas-engine specially balanced. The power is

transmitted through a 3-inch countershaft, on which is keyed a 5-ft. flywheel weighing six cwt. Both dynamos have also balance-wheels fixed to them, so that by these precautions an absolutely steady current is obtained, notwithstanding the unequal motions incidental to gas-engines.

The engine-room is a neat brick building, 24 ft. long, 12 ft. wide, and 10 ft. to eaves, and is in the grounds, very near to the main buildings and close to the adjoining street, so that it became of importance that the noise of the engine should not disturb the inhabitants. To accomplish this, three exhaust boxes and one large quieting chamber, supplied by Crossley Brothers, are used, and the result has been quite satisfactory.

A Pilsen lamp in the garden, suspended from an iron pole, has a fine effect on the trees and grass. Formerly there was no light at all in the garden.

A summary of the installation shows, for the electric light, six Pilsen arc lamps of 1,000 candle-power actual, equal to 6,000 candles; 109 incandescent lamps of 20 candle-power, equal to 2,180 candles, or a total of 8,180 candle-power, against 353 gas-jets formerly used, giving, say, 10 candle-power each, or a total of 3,530 candles.

Careful readings have been taken every night of the gas consumed by the engine, and estimating as nearly as possible the number of hours that the light will be used during the year, and taking gas at 2s. 10d. per 1,000 ft., which is the price in Oxford, it was found that the annual cost of gas will be about £70. To this must be added about £120 for carbons and attendant's wages and other expenses; thus we get a total of £190 per annum. The gas-bill paid by the society has been £250 per annum, so this leaves a margin for depreciation of electric plant.

Assuming that the cost of the electric light, with depreciation and interest, is the same as the cost of gas, the difference in favour of the electric light is very remarkable, giving nearly three times the light with all the advantages of pure air and decreased expense in redecorating; whilst the many valuable books in the society's library are preserved, and for fine art studies the colours can be seen as well by night as by day. This installation is in every way noteworthy, as indicating what can practically be done with electric light, and completely solves the question as to their relative cost.

The work has been carried out by the Pilsen Company, under the superintendence of Mr. D. E. Smith, one of the company's assistant engineers, and we shall be glad to hear of further work of a like nature being carried out by the company. There is no doubt that installations of this character are much more satisfactory in every respect than those of street lighting, which at present offer but little advantage.

On the Unequal Heating of the Electrodes by the Electric Discharge.—By Giovanni Mugna.—The electrodes of the Holtz machine consists of two equal hollow metal spheres standing upon glass rods capable of a sliding movement. The interior is connected by caoutchouc tubes with a slender U-tube, in which a short column of alcohol moves up and down.

In experiments with a Ruhmkorff inductorium, fitted with Ruhmkorff interrupter, one of these spheres was combined directly with the one pole and the other with the remaining pole, but with the intercalation of a galvanometer. With increasing intensity of the current, and at the same distance of the electrodes from each other, the excess of heat at the negative electrode, as compared with the positive electrode, increased. The result was the same if the intensity was constant, but the distance of the electrodes was lessened.

On using a Holtz machine, with or without the introduction of the condensers, the same result as above was found with respect to the influence of distance. With the condensers the negative electrode showed a much greater excess of heat over the positive in equal times than without them. If one of the globular electrodes is provided with a point the other electrode is more strongly heated.—*Wiedemann's Beiblätter.*

constant production, and giving it out when the demand rises above that production; but even here the results from experiment made greatly disappointed the expectations. So it will be as long as the accumulators remain in the present state of perfection—different from the general belief entertained by many when they were first announced by a letter in the *Times*, from a great physicist, that boxes containing a million foot-pounds of stored-up electric energy were received in Glasgow from Paris—though, even as they are, there is a large field to utilise them for other purposes than the above.

Supposing by some means or other the difficulty of supply was overcome, the next would be, how to measure and record a true equivalent of the light produced? This is not so easy to answer as it would appear at first sight.

It has been shown that the candle-power produced in an electric lamp (say, incandescent) is not proportional to the strength of the current passing through it, consequently a meter that measures and records the sum of the strength of the electric currents cannot measure an equivalent of the light produced; hence other means must be resorted to.

It has been said and shown, I believe, that the light produced in a lamp is proportional to the product of the current and pressure, or electric energy as it is sometimes called.

Although this product is a good step towards the real value (and I believe that there is a short range which is proportional), it cannot be accepted, for a long range, as the correct measurement of the light obtained unless it should be connected with that function, I believe, yet undetermined, consequently a meter which measures such a compound for a long range cannot give a true equivalent of the light produced.

Energy-meters, or erg-meters as they are called, would be quite what is required if the electrical supply was only used for mechanical and other purpose other than light.

Suppose in a parallel system a constant difference of potential was maintained between the mains, and all the lamps constructed to give their maximum efficiency for light with the same difference of potential (leaving only a small margin for an accidental increase of difference of potential, to prevent destruction of the filaments), of what use would an "erg-meter" be in this case? A clock-recording current meter would be sufficient for all the necessary measurement, with the advantage over the former of not having a leakage, and an installation with hundreds or thousands of meters would hardly satisfy the suppliers to have a leakage at every meter.

In conclusion, electric light supply, far from being perfected, has still to struggle for it, and "shareholders in connection with its financial stage must be patient and wait for their promised land."

If installations are made to light a constant number of lamps, such as the street lamps, the supply would escape from the above difficulties, and where motive power is available at a little cost they can be greatly disregarded.

A. E. Conti.

The Prospects of Electric Lighting.

Twelve months have nearly passed since the rage for forming electric light companies began, and any inventor holding a patent for electric lighting apparatus of almost any kind was eagerly sought after, with the object of forming some sort of an electric light company.

The public were promised all kinds of wonderful things, electric light and power being the most prominent; coal gas was to be one of the relics of the past, and electricity was to reign supreme as an illuminating agent; all this was promised and more, within the space of a very short time.

How do matters stand now? The public have been looking forward for the promised supply of electricity, they have also been desirous of seeing a street or a terrace of houses lighted internally and externally by electricity, and that too, at a price that should favourably compare with coal gas.

It is true that a few streets have been lighted experimentally, but as yet it has not been shown that a street can be lighted, with houses on either side, and be solely dependent upon a central station for its supply, to the entire exclusion of coal gas; all this has been proposed and talked of, yet with all the capital invested in electric lighting companies it has not yet been shown to the public that even a small terrace of twenty houses can be effectually lighted and dependent upon

a constant supply of electricity, in the same way that they are with coal gas.

We have heard, and still hear very promising results by the use of the accumulator; it is also true that a few private gentlemen have fitted up their houses with a set of accumulators, a gas-engine, dynamo, and the other necessary appendages so that they enjoy the luxury of lighting by incandescence.

This is all well and good for those that can afford to pay for such a luxury, but what is desired by the public that are in favour of electric lighting, is to see a number of houses lighted in a thoroughly reliable and efficient manner by the incandescent light, and the exterior by means of the arc light; let the interiors be lighted by the current obtained from accumulators charged during the daytime, and exteriors lighted by means of the arc light, obtained from the same dynamos working during the night.

When such has been accomplished and proved to be all that is claimed for lighting by means of electricity, then electric lighting will stand a better chance of immediate adoption, than it does at the present moment. It would have been a wise thing for some one of the electric lighting companies to have proved to the public that such could have been done efficiently, safely and thoroughly certain, instead of frittering away their large and liberally subscribed capital, as appears to be the case at the present moment.

Whether the large sums of money invested in electric lighting at the present moment have fallen into the hands of those that are better versed in the manipulation of companies, than into the hands of men that would and could make electric lighting a practical and commercial success, is only the matter of a very short space of time to show.

Many have looked forward to the time when the great discovery of that world-famed prince of chemists and electricians, Michael Faraday, would be applied for producing the most beautiful of all artificial lights readily and cheaply, wherever desired, twelve months since, appeared to promise that the time had arrived when this great discovery would receive the long looked for universal application that it deserved; but instead, it seems that it has only been employed as a bait in the hands of the unscrupulous speculator and company promoter, to make a large sum of money out of the public, and thus Faraday's discovery has all the appearance of being employed only to a very limited extent. It is true that the application of the Electric Lighting Act may be used to a great extent as an excuse for delay, but up to the present it seems that there has not been any inclination to show or prove that that which was claimed for electric lighting can be accomplished to such a trustworthy extent as is the case with other artificial illuminants; perhaps the nearest approach to what is desired has been the lighting of the Holborn Viaduct and a few of the shops on either side; but before electric lighting can become general, it must be proved to be quite as safe, and as certain as coal gas and as cheap or cheaper, and unless this can be shown and proved in a satisfactory manner, with the enormous amount of capital already subscribed for the purpose, electric lighting companies cannot expect to gain much, either in profit or public favour. It is not at all likely that every person that is desirous of employing the electric light will lay down an engine and all the necessary plant to obtain it, any more than they would think of erecting their own gas works; so that, unless it can be clearly and quickly shown and proved that electricity can be employed as a cheap, safe, and efficient illuminator, and supplied as easily as coal gas, there appears to be a near prospect of electric lighting, and some of the companies promoted for the supply of electricity, ending in lamentable failure, instead of what was hoped to be one of the most brilliant successes of the nineteenth century.

A. J. Jarman.

Ball's Dynamo-Electric Machine.

As a certain amount of discussion has arisen in the pages of your journal as to the merits of Ball's so-called Unipolar Dynamo, I should like to be permitted to give publicity to an opinion I have formed with regard to it. Having carefully perused both accounts, it occurs to me that there is nothing extraordinary in the comparatively high figures obtained by Mr. Sabine, and that the cause is not far to seek.

It is a well-known fact that up to a certain limit the

intensity of a magnetic field increases with the length of the iron core producing it, and that with a given quantity of wire better results "within this limit" are obtained with a long thin core than a short thick one.

It therefore appears to me that the results obtained from the Ball machine are due not to any newly discovered unipolar properties, but to the simple fact that the field-magnets being longer than usual, one pole is capable of producing nearly as strong a field as two short ones. Consequently two armatures revolving respectively before two such poles would develop as strong a current as the same armatures revolving in the ordinary manner, each between a pair of poles of half the magnetic intensity with a given expenditure of power.

F. W. Cooke, A.S.T.E.

G. N. R., Retford, April 10th, 1883.

[In our article of last week we called attention to the point to which our correspondent refers.—EDS. ELEC. REV.]

Information Required.

As a subscriber to the TELEGRAPHIC JOURNAL AND ELECTRICAL REVIEW, I beg to ask you for some information.

In the journal of the 24th March (page 247) "Das Telephon," in his article on telephones, mentions among others the Lockwood and Bartlett and W. C. Barney apparatus, with which trials have been made upon ordinary telegraph wires of considerable length, and surrounded by a great number of other conductors. Could you not inform me where I could procure these apparatus?

Collette,

Chief Inspector, Technical Service,
Netherlands Telegraph.

La Haye, April 7th, 1883.

[We beg to refer our correspondent to Major W. C. Barney, whose address is Dawes' Library, Baker Street, London, W.—EDS. ELEC. REV.]

NOTES.

Electric Lighting.—The Western Edison Light Company has closed a contract for installing a plant of seventy lamps in the Merchants' National Bank building, Chicago, to be operated from machinery in the basement. This company is also pushing to completion a plant of seven hundred lamps in Haverley's Theatre and two hundred and fifty in the American Express building.

The Edison Electric Illuminating Company of Boston was organised in that city on March 28th. The capital is 1,000,000 dols. A central lighting station will be immediately established in the business portion of the city with a capacity of 20,000 lights.

The Edison Electric Illuminating Company of Danville has just been organised by some of the principal capitalists of Danville, Penn., with a capital stock of 50,000 dols. Arrangements are being made to build a 200 horse-power engine and all the necessary equipments.

The surface works at the mine of the Band and Albion Company, Redan (says the *Ballarat Star*) were on the 1st February successfully lighted by electricity by the Australian Electric Light Company. Forty-one lights, which were enclosed in Swan's patent lamps, were distributed over the crushing rooms, engine, and boiler sheds, changing room, shafts, and beams. The current was generated by a dynamo-electric machine, the field magnets being excited by a small separate machine.

The experimental lighting of the Aberdeen New Market last week was satisfactory. It is the prevailing opinion that the electric light will be permanently adopted.

At the forthcoming coronation of the Czar the walls and towers of the Kremlin will be illuminated throughout with various coloured lamps, while the towers of the Assumption and of John the Great will be outlined with 3,500 Edison lights, and four electric suns, of the power of 40,000 candles each, which are being placed on the four turrets on the outer walls.

The experiment of electrically lighting the dining-room and libraries of the House of Commons has, it is stated, cost more than £2,000, but that the Commissioner of Works contracted to pay a sum not exceeding £900.

According to the *Sydney Morning Herald*, the project for the formation of Edison's New South Wales Electric Company has been withdrawn from the markets.

At the United Wards Club meeting last week a short discussion took place on electric lighting, it being urged by a member that Fleet Street was better illuminated with gas than Ludgate Hill was with the electric light. The lamps were, he said, too far apart and not sufficient in number. The majority of the members spoke in favour of the electric light.

The St. George's Vestry had under consideration last week a letter from the Brush Electric Lighting Company with reference to the Bill they intended to promote, and appointed a committee in conjunction with the vestry clerk to obtain an interview with the Parliamentary agents and ascertain how far they intended to meet the requirements of the vestry.

Mr. Edward H. Johnson, the Vice-President of the New York Edison Electric Light Company, and a gentleman well known to English electricians, is again in London, and in the *Times* of Saturday last a long letter on electric lighting appeared from his pen. Mr. Johnson deals chiefly with the methods of charge which will best develop and insure to the users of the electric light the benefits of economic improvements. He says:—"In the Edison system the standard lamp is of 16 candle-power. This lamp requires three-quarters of an ampère of current to yield 16 candles of light per hour. The bill to the consumer is based upon these known standards. If the consumer has reason to question the accuracy of his bill, he has only to count the number of lamps in use for a given number of hours, multiply the two together, and the total by 16 (the standard of the lamp), and he will have an absolute check. For illustration, the undertakers present a bill for 48,000 candles of light. The consumer counts his lamps and takes note of the number of hours they burn, and finds that he has 10 lamps burning 10 hours per day, or one lamp for 100 hours. This for 30 days gives him 3,000 lamp-hours. This, multiplied by the company's own standard of 16 candles, yields 48,000 candles, and he has proof positive that the bill is correct. If the bill were more, he has proof of its error, which the undertakers would be bound to accept, since no matter what number of ampères of current the meter may have shown to have passed, the calculation of the amount of light supplied is made from the basis of so much current per lamp to produce 16 candles of light per hour. If the undertakers object to the consumers' count, they can make it themselves, or in other ways test the accuracy of their meter.

"Compare this with the check upon a gas-meter. The bill is for 2,400 feet of gas. An examination of the meter shows the record to be in accord, but does that prove that the consumer has had 48,000 candles of light? No; the larger proportion of his gas may be escaping, and not supplying light at all. Or, if not escaping, his burners may be so wasteful that instead of getting 16 candles from a 6-foot burner, he may, as we all know, be only getting eight or ten.

"Why then perpetuate a crude and imperfect system offering no real check, when a perfect and absolute one is available? The candle-power of the lamps may be tested in many ways, but this, like many other details, takes care of itself where the undertakers are interested in their efficiency. If the lamps were under candle-power it would be because an insufficient current was passing through them. This would show upon the meter, and the bill would be proportionately decreased—a matter which the undertakers would speedily remedy in their own interests. If they were above their proper standard, thus giving the consumer more light than he desired to pay for, the lamps would be more quickly destroyed, and since the Edison system contemplates the supply of lamps free of charge to the consumers, it would speedily remedy this defect to save itself a heavy charge for lamp breakages." In some further remarks on the question of a direct supply without the intervention of storage batteries, Mr. Johnson says, in reference to electric lighting in New York:—"Mr. Edison has fully overcome all diffi-

culties, as is proven by the fact that he is now supplying 400 customers from one station, the current ramifying through a network of over 24 miles of underground wires, and over 100 miles of house wires, without the loss of sufficient current on the whole system to keep alight a single lamp, and this current has been maintained without a moment's interruption since the 4th day of September last, varying in quantity, of course, directly proportioned to the number of lamps alight at any one time; and, further, that since any other than a direct distribution means a re-distribution, and re-distribution means more or less loss or waste of energy, it follows that the direct system is the economical one, therefore the one best able to give cheap light."

Our readers will remember that the Brush Electric Light Company recently received permission from the Lambeth Vestry to erect a standard lamp in Brixton Road. We are now informed that the Fyfe-Main Electric Lighting and Construction Company has erected to the order of Mr. Clarke, jeweller, Brixton Road, a lamp-post for electric light. This is the first electric lamp fixed in the parish of Lambeth for street lighting.

Recently an engine attached to one of the dynamos in the Edison Central Station, Pearl Street, New York, ran, we are informed by the secretary of the Edison Electric Light Company, for seventeen days and nights successively, with a load varying from a minimum of 40 H. P. to a maximum of 150 H. P. indicated. The engine which accomplished this feat is a "Lawrence" direct-acting high-speed engine, running at 350 revolutions per minute, made by Messrs. Armington & Sims, of Providence, R.I. If we suppose, says our informant, the engine to have had a 5-ft. driving-wheel attached, this performance would have been equivalent to that of a locomotive making the circuit of the globe at the equator. It should be added that the bearings of the engine when stopped were not found to be unduly heated.

On Wednesday evening we visited H.M.S. *Rainbow*—the floating station of the Royal Naval Artillery Volunteers—lying off Waterloo Bridge. For several evenings during the week the members of the corps have invited their friends to witness a series of private theatricals, the stage and body of the ship being illuminated by the electric light. The installation is interesting, as the current is derived from large primary batteries, supplied by the Duplex Company, of Soho Square. The total number of lamps fitted up was 40. These were of Swan's 10 candle-power type, each lamp requiring an E.M.F. of 26 volts, and a current of 1.3 amperes. Only 16, however, are ever in use at the same time, and they are worked from stage to auditorium; and *vice versa*; also to floats and flies and ghost lights as required from a switch board alongside the stage. During our stay the lamps were at times certainly much above 10 candle-power each, and the whole effect was exceedingly good.

The order to carry out the work was only received at one o'clock on Wednesday week last, and by six o'clock on the Thursday the arrangements were complete, thus showing that orders for temporary lighting, for instance for balls, dinners, &c., may be efficiently and easily carried out without steam-power. A novelty shown here, for the first time, was a very pretty pendant, resembling an ostrich egg, suspended by gold and silk filigree network, entirely without any brass or other fittings, the lamps being supplied through flexible wires hidden in the silk. This design, of Eastern appearance, was prepared by Mr. Vander Weyde, of artistic and photographic renown.

The fitting up and superintendence of the electrical arrangements throughout were in the hands of Mr. C. J. Wharton (himself a naval volunteer), of Messrs. Laing, White, & Wharton, Holborn Viaduct. From what we can learn, it appears that the batteries of the Duplex Company are particularly well adapted for this temporary kind of work, and Mr. Wharton thinks that the 18 or 20 cells he was employing on the evening in question would have kept the lamps in operation for 10 hours or more without any recharging.

The United Telephone Company.—The officers and employés of this company on Tuesday presented to their chairman, Mr. James Brand, through their managing

director, Mr. Joseph B. Morgan, a handsomely-illuminated address. The address stated that it was felt that the rise, progress, and development of the United Telephone Company were mainly owing to the indomitable energy, pluck, and manliness which had been shown by the chairman, coupled with an honesty of purpose that had confounded the enemies and increased the friends of this novel undertaking.

Telephone Rates in Scotland.—The following appeared in a Glasgow contemporary on the 10th inst.:—Sir,—I find many of my business friends are ceasing their subscriptions to the Telephone Exchange. Why? Because the annual rate (£20) is too high. My firm gave it up two years ago for the same reason. I am convinced that the Telephone Exchange Company would double and more than double their subscribers if they reduced their rate to one-half (£10).

The Broughty Ferry Commissioners and the Telephone.—At the monthly meeting of the commissioners on Monday, the chairman reported that he had seen the manager of the Telephone Company regarding the price of a wire for the commission. It would cost £7 10s., the usual price, and the company were to pay 1s. for every pole erected. The commissioners declined the terms.

The Telephone and the Coronation of the Czar.—The Moscow palaces and the house of the Minister of War are being connected by telephone.

The Wolverhampton Chamber of Commerce and Telephonic Communication.—At a meeting of the Wolverhampton Chamber of Commerce, last week, a memorial to the Postmaster-General, in favour of additional facilities for telephone communication in the district being granted, was signed by the President on behalf of the Chamber.

Camberwell Vestry and the Telephone.—The Camberwell Vestry, at their meeting last week, agreed to an application from the United Telephone Company for permission to erect an iron pole at Linden Grove, Nunhead, to carry a wire connecting the Nunhead Waterworks with the Kennington Fire Station. It was also agreed that a telephone be provided for use at the Vestry Hall at an estimated cost of £20 per annum.

The Telephone in France.—The *Figaro* maintains the accuracy of its news, which was contradicted by the *Temps* last week, respecting the proposal to introduce telephones in Paris, worked in connection with the telegraph service, but adds that in consequence of the lack of space at the existing telegraph offices, the arrangements will be carried out at the offices of the Compagnie Générale des Téléphones.

New Telephone Relay and Loud-Talking Receiver.—An interesting feature of a series of experiments made at New York on the 22nd ult., by the National Secret Telephone Company, in telephoning to Cleveland, was the employment for the first time of a telephone relay, receiving the words in a local circuit, after the fashion of a Morse sounder, so that the reinforcement of the electric current increased the volume of tone at the receiver. Another new thing, the invention of Mr. C. A. Randall, general manager and electrician of the National Secret Telephone Company, was a loud-talking receiver. In receiving messages from Cleveland, although the instruments were not perfectly adjusted for so great a distance, words were heard distinctly with this receiver at a distance of six or eight inches from the ear.—*American Press*.

The Baxter Transmitter.—Mr. Lester Baxter, the inventor of this transmitter, by which long-distance conversation by telephone is made possible, is a clerk in the Surgeon-General's office, at Washington. In reference to his transmitter, he says that one of the most important differences between his invention and the Blake is that whether the speaker talks in a whisper or shouts close to the diaphragm the same is heard equally well through the Baxter

transmitter, while a loud tone spoken to the Blake transmitter will so agitate the current as to make hearing an impossibility to each other by wire.—*American Press*.

Telegrams.—The Indian Government has decided to allow newspaper managers to telegraph instructions to their correspondents at the usual press rates.

The Telegraph Service Revenue.—An abstract of the gross produce of the revenue of the United Kingdom in various mentioned periods has just been published, and states that that of the telegraph service in the year ending March 31st last was £1,710,000, as compared with £1,630,000 in the year ending March 31st, 1882, an increase of £80,000; and that in the quarter ended March 31st last, £395,000, as against £375,000 in the corresponding quarter of 1882, an increase of £20,000.

Telegraphs in Siam.—We read the following in *La Lumière Electrique*:—"The Government of Siam has just concluded a contract with the Eastern Extension Company for the erection of telegraph land lines and the laying of submarine cables, which will form a duplicate route from China and other countries to Singapore. The new route will include a cable from Penang to Quedah, and then a land line across the peninsula to Singora, in the Gulf of Siam. From Singora a cable will be laid across the gulf to Bangkok. The French Government, on their part, will connect Bangkok with Saigon by means of a land line which will run through Cambodia.

The International Telegraphic Convention.—The West India and Panama Telegraph Company has joined the International Telegraphic Convention.

Extension of the French systems of underground telegraph lines.—An underground telegraph line will shortly be laid between Nice and Grenoble, along the Government route No. 85. The cables will be laid at a depth of 80 centimetres under the highway.—*La Lumière Electrique*.

Personal.—Mr. C. M. Hooper having resigned, the directors of the West India and Panama Telegraph Company have appointed as Secretary Mr. R. T. Brown, formerly the company's general superintendent in the West Indies.

The Queen has been pleased to confer the honour of knighthood upon Professor Frederick Augustus Abel, C.B., F.R.S., in recognition of valuable services rendered by him to the War and other Governmental departments, in his capacity of War Department chemist.

The Vienna International Electrical Exhibition.—The Emperor of Russia has allowed the Imperial Russian Technical Society at St. Petersburg the sum of fifteen thousand roubles to form a Russian section at the International Electric Exhibition at Vienna. Mr. Welitsek, who represented the Russian department at the Paris Exhibition in 1881, has been intrusted with the organisation of the Russian exhibition group.

Post-office Cables.—The s.s. *Dacia*, Captain P. M. Hayward, chartered by the Post-office for the submersion of a new cable between England and Ireland, and for repairing the Dublin and Isle of Man cables, left her moorings yesterday afternoon for Greenhithe, from whence she sails to-day (14th) for the Irish Channel.

The new cable, some 64 miles long, has been manufactured by the Silvertown Telegraph Works, and contains four conductors. It will be laid from Wexford to Fishguard Bay. The existing cable goes from Wexford to Abermawr Bay, and the former will therefore be north of the old one.

The *Dacia* also takes out some six miles of new seven-conductor cables, manufactured by Messrs. Siemens Bros., to repair the Dublin cable, which, we understand, is broken in two different places. From the Post-office Cable Stores the necessary cable is taken on board to repair the Isle of Man cable.

The British Electric Light Company (Limited) and the Electric Power Company (Limited) v. the Anglo-American Brush Electric Corporation (Limited).—At the sittings in Banco of the High Court of Justice on the 4th inst., before Mr. Justice Watkin Williams and Mr. Justice Mathew, Mr. Moulton moved the Court on behalf of the defendants on appeal from an order of Mr. Justice Hawkins, made at Chambers, affirming one made by a Master refusing to order the plaintiffs to give security for costs. The learned counsel said he relied upon an affidavit made by Mr. Cordner, the general manager of the defendants, who stated his belief that neither of the plaintiff companies had any assets available for the payment of the costs of this action in the event of the verdict being in favour of the defendants. Mr. Cordner's affidavit was, further, to the effect that the Electric Power Company had a capital of 5,007 shares of £10 each, of which all but seven had been fully paid-up, and that he believed they were without either property or assets to answer the costs of this action; that the British Electric Light Company had a nominal capital of £100,000 of £10 each, of which on July 27th, 1882, 7,221 shares had been issued and fully paid-up, with the exception only of a sum of £610, due on calls not paid. Mr. Cordner also swore that he had been informed and believed that the British Electric Light Company (Limited) were carrying on this action by the aid of funds subscribed by their shareholders and others. The learned counsel said that the costs of the defendants had already amounted to £1,800, and would amount to a further sum of at least £2,000, as the litigation, involving as it did the whole question of the patent rights in dynamo machines, must necessarily prove to be of the most expensive character. Without calling upon Mr. Carpmal, who appeared for the plaintiffs, the Court dismissed the appeal, with costs.

A Shameful Trick.—A shameful trick (writes the Paris correspondent of the *Times*) has been played on the Academy of Sciences. The Königsberg student, Hermann Minkowsky, who, with the late Prof. Henry J. S. Smith, was declared to have gained the great mathematical prize of 3,000 f., had simply pirated Prof. Smith's communication to the Royal Society, in 1868, on the representation of a number as the sum of five squares. He had even copied a slight error in it. The Academy, therefore, at a secret session on Monday, annulled its original decision, and decreed that the whole prize had been gained by the distinguished English Professor, who, unfortunately, has not lived long enough to expose the hoax.

A Discovery.—The spire of the General Assembly Hall, Edinburgh, has just been fitted up with a new lightning conductor. Some doubt having been expressed, says the local press, as to the efficiency of the old conductor, it was resolved to subject it to a strict test, and for this purpose a copper wire was carried up one side of the spire and attached to the conductor on the other side. When the connection was effected, the electrical resistance is said to have reached the "very alarming amount of 800 ohms." The conductor was jointed together by screw couplings, and this extraordinary resistance is explained to have been due to the "defective character of many of those couplings."

OFFICIAL RETURNS OF ELECTRIC COMPANIES.

Eastbourne Electric Light Company (Limited).—The annual return of this company, made up to 31st ult., was filed on the 7th inst. The nominal capital is £50,000, in £10 shares, of which 491 have been taken up and the full amount paid thereon. Offices, Grove Road Chambers, Eastbourne.

Incandescent Electric Lighting Company (Limited).—The first return of this company, made up to the 4th inst., was filed on the 5th inst. The nominal capital is £250,000, in £5 shares; but the only shares at present subscribed are the eight taken by the signatories to the Memorandum and Articles of Association. Registered office, Cambridge Street Works, Birmingham.

NEW PATENTS—1883.

1684. "Electric lamps or lighting apparatus." E. LUMLEY. Dated April 4.
1685. "Apparatus for dividing, edge trimming, winding, unwinding, cutting, and rewinding sheets or layers of paper, silk, canvas, cloth, india-rubber, and other materials used in printing, telegraphic recording, covering cables, and other purposes." E. H. C. COLLEY. Dated April 4.
1701. "Apparatus for actuating electric bells and electric indicators." H. J. ECK and D. J. and C. B. CALLOW. Dated April 4.
1704. "Appliances for conducting and controlling electric currents." J. M. M. MUNRO. Dated April 5.
1710. "Apparatus and processes for generating and promoting electric and chemical action, and producing various products of such action and of electrolysis." S. J. WALLACE. Dated April 5.
1736. "Dynamo-electric machines of Paccinotti's sort." M. DEPREZ. Dated April 6.
1737. "Apparatus for transforming electric currents." M. DEPREZ. Dated April 6.
1745. "Electric lighting." F. H. VARLEY. Dated April 6.
1753. "Electric arc lamps." J. T. KING. (Communicated by J. R. Finney.) Dated April 7.
1754. "Electrodes for electrolytic and like purposes." F. E. ELMORE. Dated April 7.
1756. "Meters for electricity, parts of which improvements are applicable to other purposes." S. PITT. (Communicated by J. Cauderay.) Dated April 7.
1759. "Improvements in apparatus for the production and regulation of the electric light and power, viz., dynamo machines and regulator arc lamps." T. WISSENDANGER. Dated April 7.
1760. "An improved method of, and appliance for feeding the carbons of electric arc lamps." J. HENRY and H. B. BOURNE. Dated April 7.
1774. "Electric arc lamps." L. B. MILLER. Dated April 9.
1776. "Incandescent electric lamps." E. MÜLLER. Dated April 9.
1783. "Machinery for covering wire or strand with gutta-percha or other material." A. C. MOFFATT and W. H. WARDALE. Dated April 9.
1785. "Secondary piles or batteries." E. G. BREWER. (Communicated by G. Arnould and R. Tamine.) Dated April 9.
1789. "Galvanic batteries." G. BARON DE OVERBECK. (Partly communicated by F. Hornung.) Dated April 9.
1791. "Application of electricity to vehicles." F. WYNNE. Dated April 9.
1794. "Secondary batteries." R. TATHAM and A. HOLLINGS. Dated April 10.
1801. "Conductors of electricity." J. G. PARKER. Dated April 10.
1803. "Dynamo-electric machines applicable to electric motors." P. M. JUSTICE. (Communicated by — Keegan.) Dated April 10.
1805. "Electric pile." J. C. MEWBURN. (Communicated by M. and P. Azapis.) Dated April 10.
1812. "Electric lamps and electric circuit connections and devices for the same." H. EDMUNDS. Dated April 10.
1814. "Meter for electric currents." A. M. CLARK. (Communicated by G. Hochreutiner and A. Boucher.) Dated April 10.
1829. "Improvements in electrical signalling apparatus, and in methods of transmitting and receiving signals electrically." B. J. B. MILLS. (Communicated by J. U. Mackenzie.) Dated April 11.
1832. "Electric lamps." J. W. SWAN. Dated April 11.

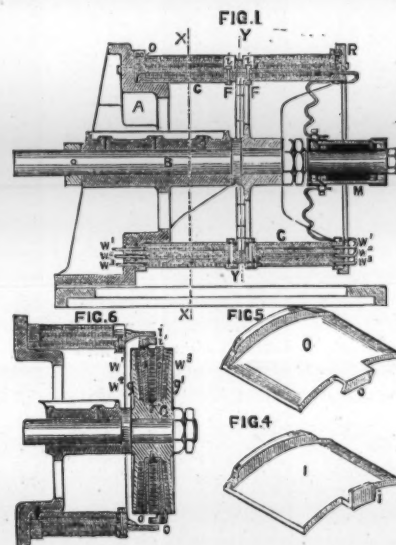
ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1882.

2512. "Incandescent electric lamps." E. W. BECKINGSALE. Dated May 26. 2d. Has for its object improvements in incandescent electric lamps. The inventor uses two or more globes or other transparent vessels, one within the other, enclosing the incandescent conductor. The inner vessel is made considerably simpler than usual for a light of a given power. The globes or vessels are made perfectly air tight and exhausted of air, so that there is void space between their parts except in such parts as is necessary to retain them in the relative position. (Provisional protection not allowed.)

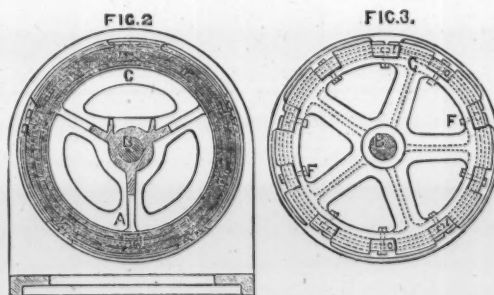
3334. "Dynamo-electric or magneto-electric and electro-dynamic machines." R. MATTHEWS. Dated July 14. 6d. Has for its object the construction of dynamo-electric or magneto-electric and electro-dynamic machines in such a manner as to accomplish the following results:—1st. In continuous current machines to be able to give a current of more uniform strength and continuity; and also increasing the efficiency of the electro-magnets in the machines hereafter described; 2nd. In alternate current machines to make the electro-magnets more efficient, and arranging part of the armature coils to be commutated into an intermittent continuous or a practically uniform continuous current to supply the electro-magnets of the machine, and the remaining armature coils commutated to give the desired alternate currents for use in the main circuit; 3rd. The construction of the commutator brushes or wheels in such a manner as is hereafter described to prevent grooving or wearing irregularly; 4th. To regulate the speed of the machine to suit the current. To

accomplish the aforesaid results the inventor arranges any number of magnets or electro-magnets so as to present any number of magnetic fields uniformly round a circle or circles presenting a number of successive fields of like polarity.

3591. "Electric producer and power machines." J. LERAY. Dated July 28th. 6d. Relates to a construction and arrangement of machines which may be employed as dynamo-electric or magneto-electric machines converting mechanical power into electricity or as electro-dynamic machines converting electricity into motive power, the object in view being to simplify the construction generally, and particularly the coiling of the insulated wire, and to utilise as far as possible the wire so coiled. Fig. 1 is a longitudinal section of a dynamo-electrical machine according to the invention; fig. 2 is a transverse section on x x looking towards the left; fig. 3 is an end view of the armature as seen on the plane, x x, looking towards the right; figs. 4 and 5 are perspective views of the segmental iron cores. Referring to figs. 1,



2, 3, 4 and 5, A is an iron frame carrying the stationary field-magnets and having in its centre a bearing for the revolving shaft, B, on which the armature is fixed. Both the field-magnets and the armature-magnets and their coils are similarly constructed and arranged, but the cores of the field-magnets may be of hard iron or steel, whilst those of the armature-magnets should be of soft iron. The construction and arrangement of these parts are as follows:—Upon a cylindrical shell, C, made of brass or other non-magnetic metal, are in the first place wound several layers of insulated wire, w¹. Over these layers are fixed the inner iron cores, I, made in segments, of which five are shown in the drawing, these segments being fixed at one end by iron screws in the case of the field-magnets to the iron frame, A, and in the case of the armature magnets to a soft iron ring, B. At their other ends the segments are fixed to the shell, C, by



bolts or screws, F, of non-magnetic metal. Each of the segments I, as shown by fig. 4, has projected forwards and outwards from its end a segmental flange, I, constituting a polar extension. Over and around the segments, I, are wound several layers of insulated wire, w², the number of these layers being preferably double that of the inner layers, w¹. Again, over the layers of w² are fixed another set of five segment cores, O, which are fixed in the same way as the inner cores, I. Each of the segment cores, O, as shown by fig. 5, has projecting forwards and inwards from its end a segment flange, O, constituting a polar extension. Again, on and around the segments, O, are wound as many layers of wire, w³, as there are layers of w¹. When electrical currents are passed through the convolutions of w¹ and w³ of the field-magnets in the same direction and through w² in the opposite direction, the segments, I and O, become magnetic, all the polar extensions, I, of the one set of segments having like polarity, and all the polar extensions, O, of the other set of segments having like polarity opposite to that of the extension, I. And, conversely, when the polar extensions I and O of the armature magnets have

opposite polarities induced on them, electrical currents are set up in the convolutions, w^1 and w^2 , of the armature in one direction, and in the convolutions, w^3 , in the opposite direction. On the face of the field-magnets on the plane, $x x$, there are thus presented five x poles and five s poles alternating with each other, and the armature presents towards these a like set of polar extensions similarly arranged. When the armature is caused to revolve so that its polar extensions, i and o , successively approach towards and recede from those of the field-magnets, the cores, i and o , of the armature have magnetism induced on them with polarity reversed as many times in each revolution as there are polar extensions to the armature cores. Thus the wire coils of the armature have set up in them alternating electrical currents which may be used in an external circuit. Or, these wires being connected to alternating plates of a commutator, x , the currents may be collected by the brushes or rubbers of the commutator, and may be led either as rapidly intermittent currents of uniform direction through an external circuit, or partly or wholly through the wires of the field-magnets. In the form of machine shown in fig. 6 the field-magnets are constructed and wound in the same way as those in the machine above described, except that the polar extensions, i and o , both project forwards, bending a little outwards and inwards respectively. The armature in this case has the form of a deeply grooved pulley having its boss, g , and side flanges, g^1 , of non-magnetic metal, and in the middle a deeply grooved pulley of soft iron which may be put on in segments. On the two side flanges, i and o , are fixed alternating with each other elbow-shaped polar extension pieces, i^1 and o^1 , also between the two flanges, i and o , and between each of them and the flanges, g^1 , are wound the convolutions of the insulated wire, that is to say, w^1 between i and g^1 , w^2 between i and o , and w^3 between o and g^1 . The action of this machine is the same as that of the machine previously described.

3595. "Electric telegraphy, &c." J. H. JOHNSON. (Communicated from abroad by E. Estienne of Paris.) Dated July 29. 1s. 2d. Relates to electric telegraphy and it consists of an improved system of signals and improvements in the construction and arrangement of telegraphic apparatus, whereby it is rendered possible to transmit messages with greater speed and precision than heretofore. In carrying out this invention reversed currents are employed, each emission being instantaneous and of the same duration. When acted on by a positive current the receiver reproduces a signal instantaneously a similar effect is produced by a negative current but a different signal is given. These two distinct signals are combined in a convenient manner to indicate letters, figures, and signs of punctuation.

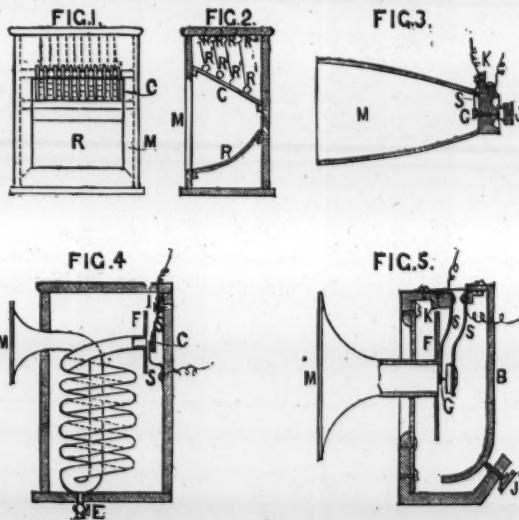
3619. "Apparatus for facilitating electric lighting." J. VERITY. Dated July 31. 6d. Relates to means for facilitating the suspension, mounting, or supporting of apparatus employed in lighting apartments and other places by the electric light.

3752. "Transmitting electricity." T. J. HANDFORD. (Communicated from abroad by T. A. Edison.) Dated August 5. 6d. The object of this invention is to produce efficient and economical means for dividing an electric current of high electromotive force or tension into a number of currents of low electromotive force or tension, and for making all the lamps, motors or other translating devices, operated by the current of lower tension, independent of each other. Such an arrangement makes a great saving in conductors, since a high tension current can be used from the point of generation to near the point of consumption, and the translating devices can be made independent by a multiple arc arrangement. According to one mode of carrying out this invention, the object before mentioned is accomplished by supplying a main circuit with a continuous current of high tension, by means of one or a number of dynamo or magneto-electric machines, and by throwing into the main circuit, at a number of points, a counter electromotive force, which causes between certain points a definite drop in the tension of the main current. From these points are run pairs of conductors; and the translating devices, such as lamps, or motors, are located in multiple arc circuits from these auxiliary conductors. Each pair of auxiliary conductors, with its translating devices, forms a shunt circuit from the main circuit. Electro-motors may be used for producing the counter electromotive force, but economy is best secured by means of secondary batteries, which can be used to supply the translating devices for a time after being fully charged. According to another mode of carrying out this invention, a similar result is obtained by arranging in series in the main circuit, a current of high tension, two or more combined electro-dynamic motors and dynamo-electric generators, each of which has two sets of coils upon its armature, connected with independent commutators. The brushes of one commutator are connected with the conductors of the main circuit, while those of the other commutator are connected with conductors, with which lamps, motors or other translating devices are connected in multiple arc circuits. Each set of coils is a continuous winding upon a cylinder or ring (the Siemens or Gramme winding) and is connected with the bars of its commutator cylinder so as to form with the common field magnet a complete motor or generator. A continuous current being passed through either set of armature coils and through the field coils, the armature will be revolved and the other set of coils will generate a continuous current by cutting the lines of force. One set of coils is in no sense secondary to the other, since they may correspond in resistance, and the electromotive force of the generating coils be the same as the drop caused by the motor coils. The field circuit of each of these machines is a multiple arc circuit from the main circuit, or from its own lamp circuit. Thus it will be seen, that each of these machines will be both a motor and a generator. The tension of the current in the main circuit is much higher than that of the current in each lamp circuit, and, since the secondary batteries, or the combined motors and generators, will be located at or near the points of consumption, a great saving in conductors can be made, since the conductors of the main circuit (the only one that need be any considerable length) can be small. Each

secondary battery can be constructed to give any desired counter-electromotive force, or each combined motor and generator can be regulated independently to give the desired tension in the circuit supplied by it, so that the same tension can be maintained in all the lamp circuits, or a different tension maintained in some so as to supply half light if required. Any one of the secondary batteries or any one of the combined motors and generators can be cut out of circuit, by closing a shunt around it, in which case the electromotive force could be reduced at the source of supply.

3802. "Secondary batteries." C. T. KINGZETT. Dated August 9. 4d. Relates to so termed secondary batteries, or magazines of electricity, and has reference to novel means and apparatus for effecting the conservation of electric energy. The invention has reference, firstly, to the particular form of the electrodes; secondly, to the compounds which are placed in contact with the electrodes; and, thirdly, to the method of the disposal of such compounds. From the results obtained in practical investigations, the inventor has concluded that while red lead may be usefully employed at the electrode, at which oxygen is set free during the charging process, it may with advantage be replaced at the other pole (where hydrogen is evolved) by the sulphate of lead, or the chloride of lead, or the oxychloride of lead, or, better still, a freshly-prepared mixture of litharge (oxide of lead) and dilute sulphuric acid.

3803. "Improvements in telephonic apparatus." SILVANUS P. THOMPSON. Dated August 9. 6d. Relates to telephonic transmitters based upon the principle discovered by Philipp Reis in 1861, namely, that of employing current-regulators actuated, either directly or indirectly, by the sound-waves produced by the voice. By the term current-regulator the inventor means a device similar to that employed by Reis, wherein a loose contact between two parts of a circuit (in which are included a battery and a telephonic receiver) offers greater or less resistance to the flow of the electric current, the degree of intimacy of contact between the conducting pieces being altered by the vibrations of the voice. In Reis's transmitter, and in Edison's transmitter, and other well-known forms of these instruments, the action is indirect, a tympanum of stretched membrane or other equivalent organ, such as a diaphragm of mica, being used to collect or magnify, or concentrate, the vibrations of the voice, and to convey them to the point or points of loose contact that regulate the current. In other forms of transmitters (for example, some of Hughes' microphones), the mode of action is direct, the air-waves beating directly upon the conductors or electrodes, which are in loose contact, without the intermediation of a tympanum or diaphragm. Of these two classes of telephone transmitters—viz., those in which the current-regulator is combined with a tympanum or diaphragm, and those in which the current-regulator is acted upon directly by the air-waves



of the voice, the improvements relate to the latter only. The inventor entirely dispenses with the membrane tympanum used in Reis's transmitter; he does not employ the tympanic diaphragm of mica used in Edison's transmitter; he does not employ the non-tympanic diaphragm of foil used in Hunning's transmitter; he does not even employ any diaphragm in the sense of a partition between the current-regulator and the air-waves of the voice, as in Theller's transmitter. In the improved transmitters the air-waves act directly upon the current-regulator itself; by dispensing with tympanums, diaphragms, and partitions he obtains a more accurate correspondence between the vibrations of the voice and the electrical undulations which they produce, than is practicable where a tympanum, diaphragm, or partition is used. As a result the articulation is clearer for some of the consonantal sounds, which are only imperfectly or difficultly transmitted by telephones in which the current-regulator is affected indirectly through a tympanum, diaphragm, or partition. Transmitters of the class to which the improvements relate are ordinarily liable to two defects. Firstly, they do not articulate so loudly as transmitters in which there is a tympanum or diaphragm to collect or magnify the vibrations. Secondly, when, to obviate this difficulty, the speaker speaks with his mouth very close to the current-regulator, the moisture of his breath condenses upon the

contact points or adjacent parts of the regulator, interfering with its action and spoiling the articulation. The improvements relate chiefly to means for remedying or obviating these defects. Fig. 1 is a front view, and fig. 2 a transverse section of an instrument constructed according to one part of the invention; fig. 3 is a transverse section of another form of instrument. The inventor proposes to employ mirrors, sound-reflectors, or reverberators (one form of which is shown in figs. 1 and 2), consisting of glass, metal, wood or other material, by which the sound-waves are turned aside from their straight or direct path and are made to converge upon the current-regulator, precisely as rays of light may be turned aside or converged by a polished mirror. If actual mirrors of polished metal or silvered glass are employed for this purpose, they have the additional advantage of revealing to the speaker the presence of moisture. But in any case the mirror, reflector, or reverberator serves to collect the sound-waves as they come from the speaker's mouth, and to direct them on to the current-regulator while intercepting moisture from the speaker's breath. *m*, is the mouth-piece or tube; *c* is the current-regulator; *r* is the reverberator; *j* is an adjusting screw; and *x* is an outlet-cock for the water which collects in the mouth-tube. The employment of flexible mouth-tubes in combination with a current-regulator without any tympanum, diaphragm, or partition, for the purpose of protecting the naked current-regulator from the deposition of moisture by the breath, is comprised in the inventor's improvements. In some cases it is found advantageous to provide the mouthpiece at its inner end with a flange, such as that shown at *f* in figs. 4 and 5, the said flange not being in contact with the current-regulator. In some of the instruments, the current-regulator consists of two pieces of metal or carbon or other conductor of electricity kept lightly in contact either by gravity or by the pressure of a light spring, *s*, or by both these agencies. Figs. 3, 4, and 5 illustrate such current-regulators. The said improvements relate further to the form of the conductors or electrodes combined to serve as the current-regulator. The current-regulator of Reis, consisting of one piece of platinum resting lightly against another, is imperfect, except when, as in some forms of Reis's instrument, one or both the pieces of metal are fixed upon springs or some equivalent elastic support; otherwise the current is liable to very abrupt interruptions. In fig. 5 is shown one of the current-regulators wherein the two contact pieces are held upon springs, *s*, *s*; one of these springs is fixed to an adjusting frame, *n*, and the other is fixed to an insulating block, *x*. Another of the improved forms of current-regulator consists of a grating or framework of prepared carbon, or metal tongues so connected that the current cannot pass from one tongue to the next except through a piece or pieces of good conducting carbon or metal suspended, or resting, in loose contact against the tongues; such regulators being combined with reverberators, mouth-pieces or tubes in the manner herein set forth. In the instrument shown in figs. 1 and 2 the current-regulator, *c*, consists of an inclined grating of carbon strips, against which the voice-waves are reflected by the reverberator, *m*, and upon which rest light balls, *n*¹, of carbon or of metal suspended from the hooks, *n*², or otherwise by silken strings.

The Eastern Extension, Australasia and China Telegraph Company (Limited).—The directors in their half-yearly report, state the gross revenue as £209,131, inclusive of Government subsidies. That total stands to be reduced to £110,755 by providing for working expenses, cost of repairs, &c., income-tax, debenture interest, and contributions to the sinking funds; while £23,468, carried over from the previous half-year, gives a total disposable balance of £134,223. Besides the interim distribution of 1½ per cent., the directors propose a further similar dividend and a bonus of 2s. per share, which, with the amount paid on account of the first half of the year, gives a total distribution of 6½ per cent. from 1882, as compared with 6 per cent. paid in 1881. The balance of £64,311 has been carried to the reserve fund, raising it to £351,034. The premium realised in the recent issue of 50,250 shares amounted to £50,250, and is also to be credited to the reserve fund.

The Eastern Telegraph Company (Limited).—The interest at the rate of 3s. per share on the 6 per cent. preference shares for the quarter ended March 31st, as also the half-yearly interest on the 6 per cent. debentures, will be paid, less income-tax, on the 16th instant, at the banking house of Messrs. Glyn, Mills, Currie and Co., 67, Lombard Street, E.C. An interim dividend of 2s. 6d. per share on the ordinary shares, in respect of profits for the quarter ended December 31st, 1882, will be paid, free of income-tax, on the same date.

The Eastern and South African Telegraph Company (Limited).—This company's cable between Zanzibar and Mozambique was interrupted on Friday morning last week. The company's repairing ship, stationed at Zanzibar, was to have proceeded as quickly as possible to restore telegraphic communication.

The Direct United States Cable Co. (Limited).—This company notifies that the half-yearly interest on their 6 per cent. debenture loan will be paid on and after the 16th inst., at the Consolidated Bank (Limited), Threadneedle Street, E.C., where coupons should be left for examination three clear days before applying for payment.

The Anglo-American Telegraph Co. (Limited).—At a meeting of the board of directors yesterday week, it was resolved, after placing the quarterly sum of £37,500 to the credit of the renewal fund, to declare an interim dividend for the quarter ending March 31, 1883, of 15s. per cent. on the ordinary and 30s. per cent. on the preferred stocks, both free of income-tax, payable on the 1st of May.

The Electrical Power Storage Co. (Limited).—An extraordinary general meeting was held at the offices of the company, Great Winchester Street Buildings, on Thursday week, Sir Daniel Cooper presiding, when the resolutions passed at the meeting on the 21st ult. were confirmed. They were for making certain alterations in the articles of association of the company, and for approving and confirming the contracts, dated respectively the 13th and the 16th of February last, made between La Force et la Lumière and another and the company, and the company and the French Electrical Power Storage Company (Limited). This was all the business.

The Indo-European Telegraph Company (Limited).—The board of this company at their meeting on Monday determined, subject to audit, and after setting aside £5,000 to the reserve fund, providing for freeholds and stores £8,301 11s. 8d. on maintenance account, and for a payment to the India Office of £6,500 on account of the Persian debt in the nature of a reserve fund, to recommend the payment for the six months ending December 31st, 1882, of 17s. 6d. per share, making with the interim dividend already paid, 6 per cent. for the year, and a bonus of 15s. per share, both free of income-tax, carrying forward £1,000 to the next account.

Settling Days.—The Committee of the Stock Exchange has appointed the following special settling day:—April 12. Eastern Extension, Australasia and China Telegraph Company (Limited), 50,250 new £10 shares, with £8 paid—to be marked. Application has been made to the committee to appoint a special settling day in the following security: Yorkshire Brush Electric Light and Power Company (Limited).

LATEST QUOTATIONS.

Authorised Issue.	Share.	Name.	Paid	Closing Quotations, April 11.	Business Done.
ELECTRIC LIGHT.					
40,000	10	Anglo-American Brush Co.	7	6½-7	62 m.
		Do. Do.	10	9-10	
30,000	5	Australasian Electric Light, Power & Storage Co.	3	1½-2	
24,900	10	British Electric Light Co., Limited, "A" Shares	5	13-24	
30,000	5	Brush Electric Light & Power Co. (Scotland)	2½	1-2	
25,000	5	Great Western Electric Light & Power Co.	2½	3-4	
24,900	5	Hammond Electric Light & Power Supply Co.	2	2-4	
40,000	5	Indian & Oriental Electrical Storage Works Co.	2	2-4	
172,500	1	Maxim-Weston Electric Light and Power Co.	1	1-2	
40,000	5	Pilsen-Joel & General Electric Light Co.	2	1-1	
100,000	5	South African Brush Electric Light & Power Co.	2½	1-2	
	5	Swan United Electric Light Co., Limited	2½	1½-2½	
TELEGRAPHS.					
2,116,400l.	Stk.	Anglo-American, Limited	100	51½-52½	
2,441,800l.	Stk.	Do. Preferred [Def'd. receiving no div. until] ..	100	83½-84½	84 m.
2,441,800l.	Stk.	Do. Deferred [6 p.c. has been paid to Pref.] ..	100	20½-21	
130,000	10	Brazilian Submarines, Limited	10	12½-13½	12½-13½ m.
16,000	10	Cuba, Limited	10	10-10½	
6,000	10	Do. 10 per cent. Preference	10	17-18	
13,000	10	Direct Spanish, Limited	9	6½-8	
6,000	10	Do. 10 per cent. Preference	10	15½-16½	
65,000	2½	Direct United States Cable, Limited, 1877	20	12½-13½	12½ m.
100,000l.	100	Do. 6 per cent. Debenture, repayable 1884 ..	100	101-104	
380,000	10	Eastern, Limited	10	10½-11½	11½ m.
70,000	10	Do. 6 per cent. Preference	10	13-13½	
232,000l.	100	Do. 6 do. Debentures, repayable Oct. 1883 ..	100	100-103	
200,000l.	100	Do. 5 do. do. Aug. 1887 ..	100	101-104	100½-101½
200,000l.	100	Do. 5 do. do. Aug. 1889 ..	100	104-107	
199,750	10	Eastern Extension, Australasia & China, Limited ..	10	11½-12½	12½ m. 12 a
50,250	100	Do. New Shares, 1883	8	8-8½	
320,000	100	Do. 6 p.c. Debentures, repayable Feb. 1891 ..	100	107-110	108½ m.
500,000	100	Do. 5 p.c. [Australian Gov. Subsidy] Deb. 1900 ..	100	104-107	
140,000	100	Do. do. registered, repayable 1900 ..	100	104-107	
100,000l.	100	Do. 5 per cent. Debenture, 1890	100	103-106	
254,300l.	100	[Eastern and South African Limited 5 per cent.] ..	100	103-106	
345,700l.	100	[Mort. Deb. Registered redeemable 1 Jan. 1900] ..	100	103-106	
22,050	10	Do. do. To Bearers ..	10	103-106	
163,390	10	German Union Telegraph and Trust, Limited	10	10-10½	
163,206	10	Globe Telegraph and Trust, Limited	10	6½-7½	
125,000	10	Do. 6 per cent. Preference	10	12½-13½	13½ m.
100,000l.	100	Great Northern	10	12½-13½	12½-13½ m.
300,000	100	Do. 5 per cent. Debentures	100	101-104	
31,200	100	Do. 5 per cent. Debentures	100	101-104	
100,000	100	India-Rubber, Gutta-Percha and Telegraph Works ..	10	29-30	29½ m.
17,000	25	Do. 6 per cent. Debentures, 1886 ..	100	103-106	
38,148	10	Indo-European, Limited	25	32-33	
12,000	10	London Platino-Brazilian, Limited	10	4½-5	
8,200	10	Mediterranean Extension, Limited	10	14-2	
9,000	10	Do. 8 per cent. Preference	10	6-7	
280,000	Stk.	Reuters, Limited	8	9½-10	
58,225	1	Submarine	100	24-25½	
4,200	1	Do. Scrip	1	2-2½	
37,350	12	Submarine Cables Trust	100	109-112	
150,000	100	Telegraph Construction and Maintenance	12	32½-33½	33½ m. 33½ a
188,750	100	Do. 6 per cent. Bonds, 1884	100	101-103	
30,000	10	Do. 2nd Bonus Trust Cert.	5	1½-1	
150,000	100	West Coast of America, Limited	10	4½-5	
69,910	50	Do. 8 per cent. Debentures	100	108-110	
200,000l.	100	Western and Brazilian, Limited	15	7½-7	7½ m.
2,500	100	Do. 6 per cent. Debentures "A" 1910 ..	100	105-108	
1,500	1,000	Do. 6 p.c. Mort. Deb. series B of 80 red. Feb. 1910 ..	100	99-102	100 a.
1,030,000l.	100	Western Union of U.S. T.p.c. Mort. (Building) Bds. ..	1,000	125-128	
88,321	10	Do. 6 per cent. Sterling Bonds	10	103-108	
34,563	10	West India and Panama, Limited	10	1½-1½	
4,689	10	Do. 6 per cent. 1st Preference	10	7½-8½	
	10	Do. 6 do. 2nd do.	10	5½-6½	
TELEPHONES.					
154,185	1	Con. Telephone & Maintenance, Ltd. Nos. 1 to 154,185 ..	1	5-13	
225,000	1	Oriental Telephone Co., Nos. 80,001 to 300,000 ..	1	5-13	10½-11½ m.
100,000	5	United Telephone Co.	5	10-10½	10½-11½ m.

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